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### THE FADES VIADUCT OVER THE SIOULE RIVER NEAR VAURIAT, FRANCE.

A bridge which is remarkable in several of its features is being built at the present time across the valley of the Sioule River, near the town of Vauriat, on a new branch railway line from Saint Eloy to Pauniat, near the railway from Clermont to Tulle, Central France, at a distance of about 100 miles from Paris. The superstructure of this bridge is a three-span continuous girder of deck type, having two multiple-web trusses. Its total length between end pins of the steelwork is 374 m. (1,228 ft.), the central span being 144 m. (472 ft.) between centers of piers, while the side spans are each 115.2 m (378 ft.) c. to c. These lengths are not remarkable in any respect, and the main peculiarity of the superstructure is that it is constructed as a continuous girder. The striking feature of the bridge, however, is its extreme height above the bottom of the valley and the use of masonry piers instead of steel towers. The level of top of rail at the center is 132.5 m. (435 ft.) above the bed of the Sioule. The two piers are correspondingly tall; from foundation level (about 20 ft. below the surface of the soil) to the top of the coping they are 98.33 m. (322.5 ft.) in height.

The accompanying general view down the valley, looking toward the site of the bridge, shows one of the piers practically completed and the other carried up within 20 ft. or so of the full height. A further impression of the proportions of one of these piers may be had from Fig. 1, showing a view of a single pier, the shore span beyond it being in process of erection.

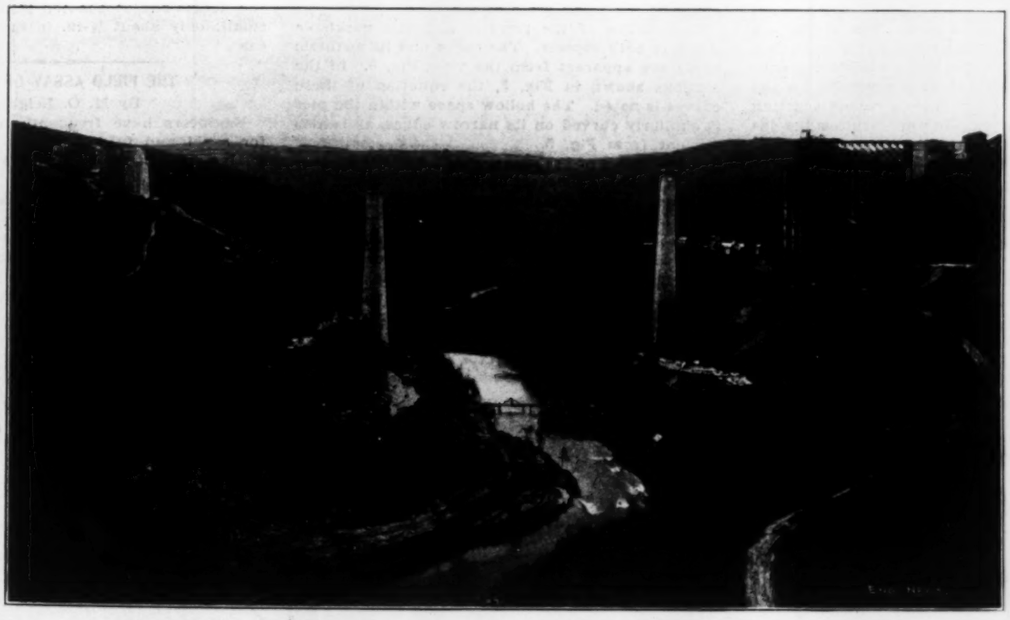
The extreme height of these piers is to be considered in connection with the fact that the bridge is a continuous structure—continuous with reference not only to bending moment, but also to temperature expansion. This continuity requires that three of the four points of support must be detailed as expansion bearings. The fixed support is located on one of the tall piers, which must evidently withstand the traction of braked trains on the full length of the bridge.

Fig. 2, an elevation of the complete bridge, exhibits the general arrangement of the structure. In plan it is a single-track railway bridge with trusses 38 ft. deep out to out, spaced 6.78 m. on centers transversely. The rails are carried directly on two longitudinal stringers which frame into transverse floorbeams lying in the plane of the top chord; the floorbeams are spaced 3.6 m. (11.8 ft.) apart. Both floorbeams and stringers are constructed as plate girders. The main trusses are lattice girders with a sixfold Warren web system, whose members have an inclination of 45°. Both top and bottom chords are of U-shape, having two webs with angles top and bottom connected by one or more cover plates on the outer face. The web members are generally of latticed four-angle section.

The superstructure has few features of special interest. There is a full lateral system in both top and bottom chord, with cross-diagonal sway frames at every fourth floorbeam, and extended gusset-plate stiffening at the remaining floorbeams. In the plane of the lower chord a footbridge is provided, supported by two lines of shallow stringers framed into the transverse members of the lower lateral system. This footbridge is 3.28 ft. in the clear between hand rails 3.28 ft. high, and is floored with ¼-in. steel plate; its principal purpose is to afford facility for inspection of the steelwork.

The rails, which as already noted lie directly over the stringers, are bolted to longitudinal wooden sleepers, which are in turn bolted to the 7-16 × 14-in. cover-plate of the stringer. A full flooring of steel plate is provided in addition. The space between the two stringers and between either stringer and the truss is spanned by plate girders 7 ins. deep. There are four such joists between two consecutive floorbeams, giving an average spacing of 29 ins. c. to c. They are framed into the stringers and the top chords of the trusses, with tops flush with the upper flanges of floorbeams and stringers. Continuous plating of ¼-in. steel is laid over the floor framing thus formed. Along the edges of the rail sleepers longitudinal angle-irons are bolted to floorplate and sleepers.

In view of the great height of the masonry piers which support the bridge, and the consequent necessity of providing effectively for expansion of the superstructure without throwing transverse loads on the piers, the details of the



GENERAL VIEW OF SITE OF THE FADES VIADUCT, NEAR VAURIAT, FRANCE.

The abutments and the 300-ft. piers are nearly completed, and erection of the steelwork on the south end is in progress.

supporting shoes may be of interest. The three types of shoes used are grouped in Fig. 3. In this drawing, A shows the fixed support used on one of the tall piers. This is a modified form of pin support with a projected bearing area of 292 sq. ins. Lugs on the upper half engage notches on the lower half, as shown, to guard against lateral displacement. At B is shown the expansion bearing used on the opposite pier. The upper shoe here consists of a modified pin support similar to the fixed end bearing; it rests on four segmental rollers having a diameter of 0.50 m. (20 ins.) and an effective length of 1.18 m. (46½ ins.). Two pairs of spacing bars enclose the rollers at the sides, being joined to them by stud pins screwed into the ends of the rollers. It will be noted that the rollers have flanges along the circular face at each end of both top and bottom segmental face, which flanges embrace both the sole plate and the bottom of the upper half of the shoe, as a guard against lateral motion of the structure. On the two abutments of the structure expansion bearings of another construction are used, C in Fig. 3. The general arrangement is similar to the expansion bearing just described, but full cylindrical rollers are used, two in number, at each bearing, of the same diameter (20 ins.) as the segmental rollers already noted, but slightly shorter bearing length (39½ ins.). The detailed arrangement of this bearing is otherwise quite similar to the segmental roller bearing. The maximum loads on these bearings are: 590,000 lbs. per abutment, or 295,000 lbs. per shoe; and 1,680,000 lbs. per pier, or 840,000 lbs. per shoe.

The design of the masonry portions of the viaduct is represented in Figs. 4 and 5. Fig. 4 gives an elevation of the abutment at the St. Eloy (north) end of the viaduct. The abutment comprises an end pier carrying the seat for the superstructure, and two arched approach spans, each 14 m. (46 ft.) in the clear each. The arches are semicircular in form, and have a cut granite facing along the intrados, backed with granite rubble. The same material is used generally for the masonry in the structure: granite rubble hearting with cut granite facing. In the cornices the individual blocks are tied together by copper cramps. The granite, obtained from a quarry in the neighborhood, showed a crushing strength of 550 to 600 kg. per sq. cm. (7,800 to 8,500 lbs. per sq. in.). This stone was laid in a hydraulic lime mortar, except in the facing, where Portland cement mortar was used. As no large quantities of suitable sand for the mortar were obtainable in the neighborhood, crushed and washed granite was used as sand in the mortar. It appeared from tests that this produced a mortar of greater strength than mortar made with selected river sand found in the neighborhood.

The piers, one of which is shown in section in Fig. 5, are built with a hollow extending up through the entire height, from the top of the footing course to within about 20 ft. of the coping level. As shown, this hollow space is rectangular, with semicircular ends. It has a constant width of 2 m. the narrow way of the pier, and a length varying from 9 m. at the base to 4.11 m. at the top. In the main, the purpose of the hollow is to save material, for given outside dimensions of pier, or conversely to give increased stability for a given amount of material. It presents the further great advantage of affording space for a central construction scaffold, whereby all outside scaffolding is avoided. There is, perhaps, a further advantage obtained in somewhat quicker drying of the mortar in the interior of the masonry. The method of working from a scaffold in the interior of the pier is indicated in the view on the first page, though details are lost on account of the small scale of the view.

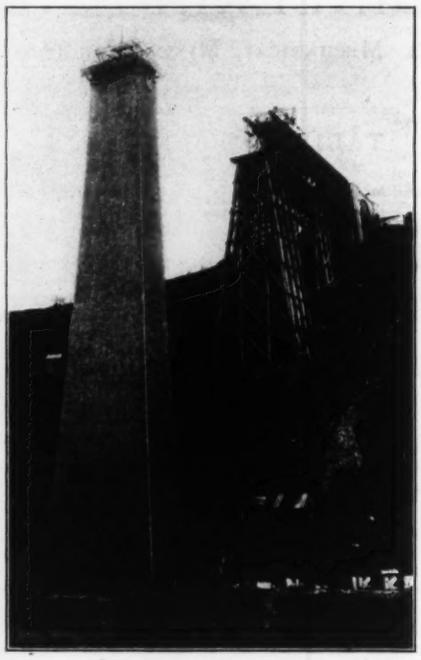


Fig. 1. View of One Pier of the Fades Viaduct.

The outline of the piers is a gentle parabolic curve in both aspects. The curve and its æsthetic effect are apparent from the view Fig. 1. In the sections shown in Fig. 5, the equation of these curves is noted. The hollow space within the pier is similarly curved on its narrow edges, as is also evident from Fig. 5.

The erection of the superstructure of the viaduct was carried out by erecting the end spans on timber falsework and then working forward in cantilever fashion over the central span. Fig. 6 shows the erection of one of the end spans in progress. The falsework carries a short section of vertical steel framework along either side, reaching just above the top flange level of the truss. On these side frames, which are connected by brace struts across the top, a gantry crane is mounted, running on a fore-and-aft track on either frame and having sufficient clearance above the permanent steelwork to be able to set all pieces. Several smaller gantry cranes run on the same track, for handling and supporting lighter pieces.

The closing of the middle span at the junction of the cantilever sections from each end will be effected by adjusting the relative heights of the two ends by means of the hydraulic jacks under the rear end of each section.

LOADS.—The dead load of the bridge, considered uniformly distributed, is 6,280 kg. per m. (4,200 lbs. per lin. ft.), or 3,[illegible] per m. per truss (2,100 lbs. per lin. ft.). [illegible] load is a train of coal cars of 20 tons ea[illegible]ch, drawn by two 77-ton engines. The [illegible] have each two axles spaced 3.05 m. apa[illegible] length of car of 7.67 m.; their maxim[illegible] load is 16 tons.

Wind pressure was taken at [illegible] per sq. m. (35 lbs. per sq. ft.) of vertical [illegible] for loaded bridge, and 270 kg. per sq. m. [illegible] per sq. ft.) for unloaded bridge. These pr[illegible] were assumed to act on the actual verti[illegible]ction only of the trusses. The full wind p[illegible]e was assumed to act upon the windward [illegible] while the simultaneous pressure on the le[illegible] truss was less by that fraction of the full pr[illegible]re equal to the ratio of exposed truss surface [illegible]ne truss to the total area of the circumscrib[illegible]figure. The wind pressure upon the train was [illegible]med to act upon a vertical surface 3 m. (10 ft.) in height, with its lower edge ½-m. (20 ins.) above the rail. It was found on calculation that the maximum wind effect is obtained when a train is on the bridge, the total pressure being then 1,385 kg. per lin. m. (930 lbs. per lin. ft.). The wind pressure is, of course, resisted by all four supports in conjunction.

The pier carrying the fixed-end bearing is further required to resist the braking effort of the full train load. It was assumed that the maximum train load provided with full complement of automatic brakes would be 330 tons, giving, with a coefficient of 0.20, a tractive effort of 66 tons.

The maximum compressive stress due to full dead and live load and full wind load is equal to 14.31 kg. per sq. cm. (200 lbs. per sq. in.). The stress due to the braking effort is only about 10% of this. Calculation for lateral deflection of the piers under wind and braking load showed that the deflections at the top would be exceedingly small; only about ¼-in. in the most unfavorable case.

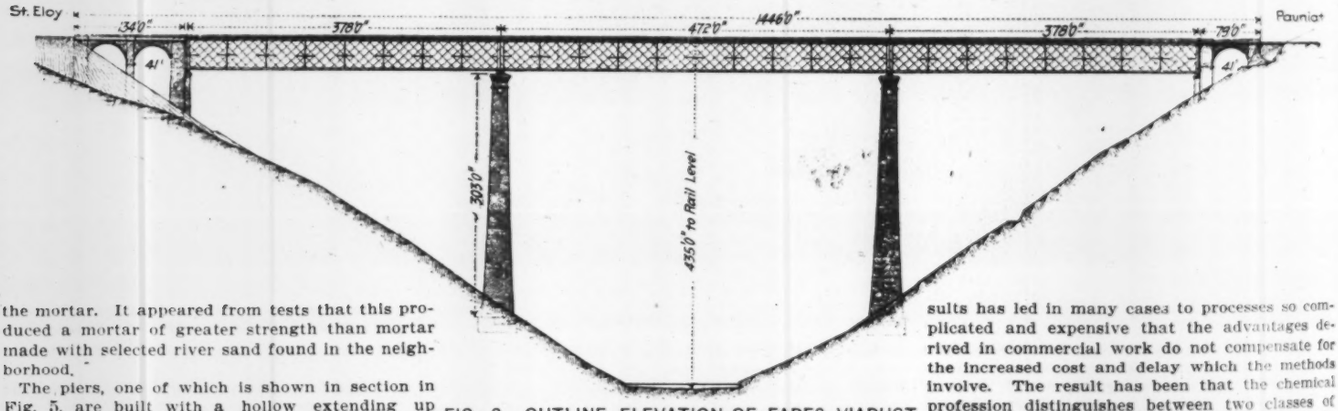



FIG. 2. OUTLINE ELEVATION OF FADES VIADUCT.

## THE FIELD ASSAY OF WATER.

By M. O. Leighton.*

Engineers have frequently expressed a desire for rapid and fairly accurate methods of water analysis which afford just the results needed in certain well-defined problems. The present chaotic condition of water chemistry is responsible for this. Usually the engineer who desires to learn something definite about a water is inflicted with an analytical report, the greater part of which is irrelevant.

The scrutiny to which chemical methods have been subjected in the endeavor to secure exact results has led in many cases to processes so complicated and expensive that the advantages derived in commercial work do not compensate for the increased cost and delay which the methods involve. The result has been that the chemical profession distinguishes between two classes of chemical methods which differ one from the other in their degree of accuracy. The first includes the exact methods which afford results as nearly perfect as chemical procedure will permit. Such methods are used in all cases where minute differences in analysis would cause errors in interpretation or in subsequent chemical procedure. The second class is made up of "commercial methods," so called because the results derived from them, while departing from the actual truth, are sufficiently accurate to insure the profitable conduct of industrial chemical processes without

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appreciable error or waste. In the great majority of water problems, "commercial methods" are sufficient for all purposes.

In the analysis of water for hydro-economic surveys, or surveys made to determine the value of water and its applicability for use in domestic supply, boilers and industries, commercial methods are more valuable than exact ones. Under the usual conditions it is necessary to resort to long, tedious and expensive processes in order to secure a determination of the character and amount of foreign constituents in water. It is the practice in such cases to secure a sample of the water and transport it to a laboratory where, after conventional delays, it is passed through the usual course of analysis. There has, in the past, been surprisingly little discrimination used with reference to the selection of determinations, and as a general rule the same procedure has been followed without regard to the object of the particular investigation. If the purpose of the analysis is to determine the incrusting constituents, the course pursued has been to follow the entire analytical procedure throughout. If, on the other hand, it is desired to determine the amount of organic pollution in a water and show its value for domestic use, the chemist forthwith begins the round of nitrogen determinations and closes with a statement of the oxygen consumed and the number of bacteria per cubic centimeter.

It is true that from a general standpoint the more we know concerning a water the better. Therefore the present laboratory practice in all its detail and precision must stand for true chemistry, and in the final appeal will be regarded as *prima facie* evidence. There are, however, many purposes of water analysis which can be served quite as well by approximate as by accurate methods.

The requisites to be met by a water in almost every line of special development except that of pure chemistry are broad and flexible. In the sanitary analysis certain results receive certain interpretations which remain generally unchanged if the results are varied by one, two, three, or sometimes even ten per cent. A strange feature in connection with sanitary water analyses is that in addition to insisting upon super-refinement, many chemists persist in making determinations that are admittedly to no purpose. It is a common thing to see an analyst's report of a water containing the results of determinations of albuminoid and free ammonia, nitrates and nitrites, together with a foot note that these results are unworthy of trust and mean very little, except to verify conclusions made from inspecion of the territory from which the water was taken. In case such conclusions do not agree with the analytical evidence the latter is invariably discredited.

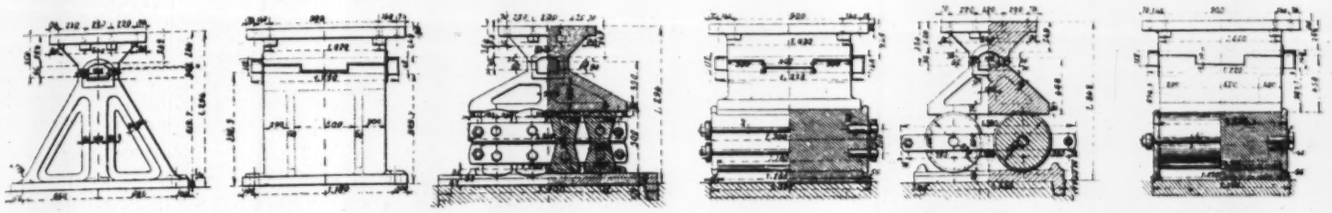
In determinations of inorganic constituents in a water it would make no difference in the decision of acceptance or rejection of that water for boiler use, if the harmful constituents for irrigation or for manufacturing were contained, for example, in the proportion of 4, 5 or 6, or of 40, 44, or 48 grains per gallon. The lines dividing good and bad water for boiler purposes are very broad. If a water contains a certain amount of incrusting constituents and a method used is inaccurate to a limit of 5 or 10 per cent., it would not lead to the acceptance of a bad water or the rejection of a good one. The "good" and "bad" provinces are approached too gradually to admit of such consequences. Besides water from a given source will often vary considerably at different seasons of the year.

Another error arises from the conventional methods of expression of results. If the analyst finds that a water contains certain amounts of calcium, magnesium, sodium and potassium and certain equivalents of the carbonate, sulphate and chloride radicals, he unites these substances according to methods which are apparently not uniform and entitled to little scientific justification. It is a well known fact that if several chemists, each independent of every other, analyze a certain water, there will almost invariably be wide differences in the expression of results. The inorganic constituents of a water should invariably be expressed as positive and negative ions, and if so expressed, the result determined according to approximate methods is as valuable as the expression of precisely determined constituents united according to the individual ideas of the analyst.

A practical disadvantage in chemical water surveys arising from the insistence upon refined methods of analysis and lack of discrimination in the choice of specific determinations is the delay which arises in securing valuable information with reference to wide areas. Months and even years have been spent upon certain water surveys covering only a comparatively small portion of country.

In the rapidly increasing army of water analysts there seems to be a general tendency to attack every water problem as though the object were to prove its fitness or unfitness for drinking purposes. In many investigations it is well known at the outset that the water cannot be used for domestic purposes and the problem is of quite another character. The conventional grind of nitrogen determinations has been made to do service in almost every conceivable water problem. It has been used frequently in investigating pollution problems in which organic matter had absolutely no part. A considerate study of the results obtained in many laboratories will show that in routine work a number of determinations might be omitted without damage. These facts are mentioned in order to emphasize the point that if care and discrimination are used in the selection of tests the work necessary in carrying on chemical surveys might be decreased and the money available for such work might be distributed over a wider field. Results of more immediate use might be secured and the completion of a chemical survey would not then be postponed for the benefit of future generations. "Commercial methods" serve useful purposes is manufacturing; the success of enormous industrial plants independent upon them; in water surveys they would at least be businesslike.

It was these considerations which led the United States Geological Survey, through its Hydro-Economic Division, to investigate the practicability of employing field methods for the determination of important characteristics of water. It was realized that if there could be provided a few simple tests, the apparatus for which could be taken into the field and used upon the spot, it would be possible to cover large areas in a short time, and if it were necessary for any reason to make periodical determinations, the cost of the work would still be small and the total would not run up into the large sums of money which have been spent heretofore in connection with such investigations. The idea itself was by no means new. Very successful field tests have been carried on by numerous authorities. They all involve the use of considerable apparatus and the carrying of standard solutions. Specially equipped wagons are necessary in some cases. In others the variety of determinations is limited or the equipment cannot be used in an extensive circuit without renewal of reagents. The difficulty of carrying standard solutions and complex apparatus into the field is well known. The ideal equipment is one which can be carried by the field man in journeys afoot without undue fatigue. It should contain a sufficient supply of reagents to serve for a large number of determinations without renewal. The processes should be rapid and the results fairly accurate and comprehensive. With it the operator should be able to cut loose from a base of supplies and proceed by foot or horse into country inaccessible to wagons, for the sources of useful or desirable water supply are not distributed with reference to railroad or wagon routes and the field man must often climb mountains or trace obscure trails to accomplish his purpose. Finally the equipment should be provided with material for so various a series of determinations that with proper discrimination the essential characteristics of a water may be shown whether the purposes be domestic or industrial water supply, irrigation or any other line of special utilization. Volumetric methods requiring the use of burettes are objec-



A.—Fixed Shoe, on Pier. B.—Expansion Shoe, on Pier. C.—Expansion Shoe, on Abutments.

FIG. 3. FIXED AND EXPANSION SHOES, FADES VIADUCT.

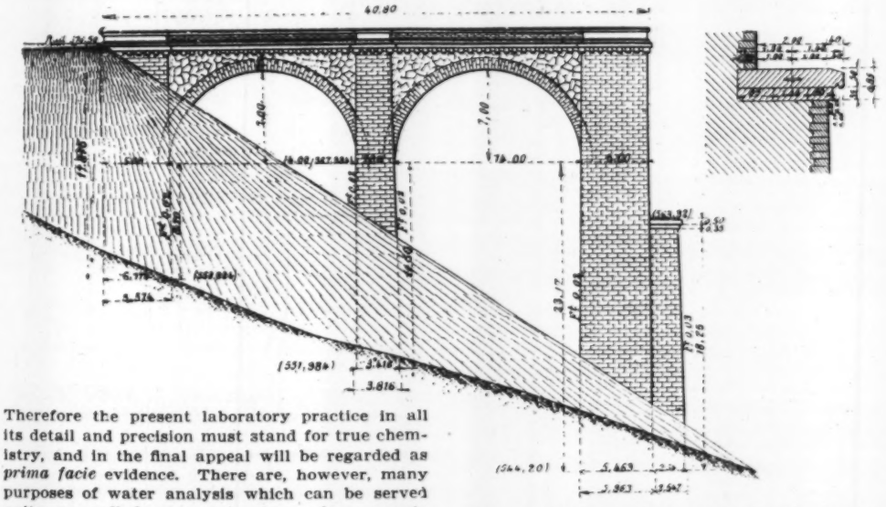


FIG. 4. NORTH ABUTMENT AND APPROACH ARCHES, FADES VIADUCT.

tionable; gravimetric methods are impossible. Therefore the whole matter developed into a question of choosing the most useful determinations, and so modifying the volumetric processes that they could be employed with accuracy sufficient for all practical purposes.

To the methods hereinafter proposed the general term "assay" readily lends itself. There is no attempt at water *analysis*. The plan contemplates the determination of ingredients which give to water certain well known characteristics. The methods themselves and the suggestions with reference to their application are probably only tentative and will certainly be changed or modified as future experience dictates. As they stand they

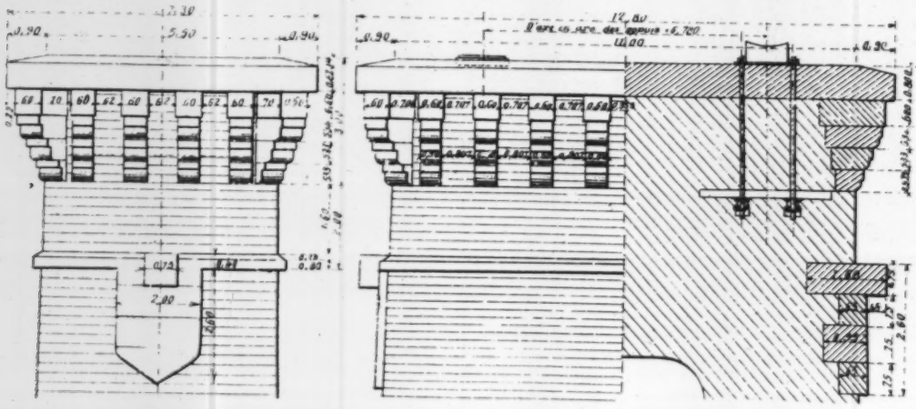


FIG. 5. SECTIONS AND DETAILS OF PIERS, FADES VIADUCT.

are the result of extended experimentation, and it has been shown that they are practicable. They have been found to be more nearly accurate than was at first anticipated, though this fact, it is believed, has not greatly increased their usefulness for the purposes in view.

The following determinations are described in the order named:

1. Turbidity.
2. Color.
3. Total hardness.
4. Alkali carbonates.
5. Normal carbonates.
6. Bicarbonates.
7. Total sulphates.
8. Chlorine or total chlorides.
9. Iron.
10. Calcium.

It should be stated at the outset that the successful operation of these methods depends, as in all chemical procedure, upon the manner in which they are applied. A failure to insist upon strict compliance with the rules laid down may give erroneous results.

## TURBIDITY.

The Hazen turbidity rod, the scale of which was modified by Hazen and Whipple to conform with the silica turbidity scale, is described in Circular No. 8 of the Division of Hydrography, U. S. Geological Survey, and designated as U. S. G. S. Turbidity Rod, 1902. This rod is very useful under certain favorable conditions. In general field work the combination of prescribed conditions necessary for correct readings, occur only in rare instances. There are many other important objections to the turbidity rod and its use by the Geological Survey is now confined to regularly maintained observation stations where it is possible to conform with the conditions imposed. In the general field turbidity measurements maintained by the Geological Survey, the turbidimeter devised by Mr. D. D. Jackson, Director Mt. Prospect Laboratory, Brooklyn, N. Y., first described by him in the Journal of the American Chemical Society, November 1, 1901, is used almost exclusively. The form of the instrument has been modified and greatly improved since the date of that article. The measurement of turbidity is determined in this instrument by the disappearance of a cross of light of standard illumination. There are two forms of turbidimeter, in one of which the source of light is a standard English candle, while in the other the illumination is derived from a dry battery with an incandescent bulb of approximately one candle power. The candle turbidimeter is by far the more accurate and should be used in all cases where the instrument can be protected from the wind. The electric turbidimeter requires frequent adjustment, as the dry batteries used vary considerably in electro-motive force. It is necessary to use the electric instrument in all cases where samples cannot be collected and carried to a convenient central point and the turbidity determined by the candle turbidimeter placed in shelter. The apparatus consists of a glass tube, closed at the bottom, and graduated in centimeters and millimeters depth. This is surrounded by a brass holder into the bottom of which is set a disk in which a standard cross is cut. The candle of the turbidimeter is then adjusted or in the case of the electric turbidimeter the electric circuit is closed and the beam of light thrown through the standard cross.

To make a turbidity determination the suspended matter in the water is uniformly distributed by shaking or pouring back and forth from one vessel to another, and is then poured into the glass tube until the sharp image of the cross is obscured. It is important to note the exact end point. If the water has a high turbidity so that the cross is obscured at a slight depth of water in the tube, the image of the cross becomes hazy at the outer ends and the haziness approaches the center until only a sharply defined point of light is visible. If, on the other hand, the water has a low turbidity and it is necessary to fill the tube to a considerable depth, the sharp outlines of the cross become hazy throughout its whole extent.

Table for Determining Turbidity from Depths Observed in the Candle or Electric Turbidimeters.

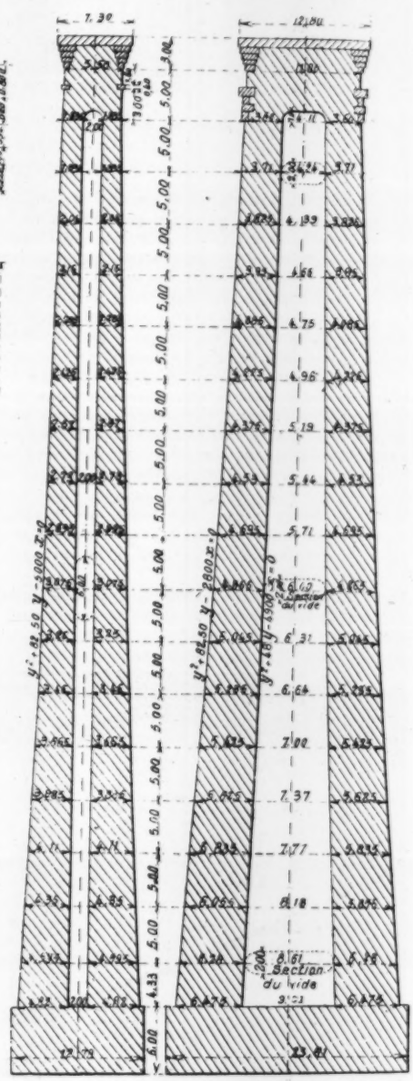
| Depth in cm. | Turbidity Pts. per Million of Silica. | Depth in cm. | Turbidity Pts. per Million of Silica. |
|---|---|---|---|
| 0.3 | 10,000 | 13.5 | 160 |
| 0.5 | 5,000 | 14.4 | 150 |
| 0.6 | 4,000 | 15.4 | 140 |
| 0.8 | 3,000 | 16.6 | 130 |
| 1.0 | 2,500 | 18.0 | 120 |
| 1.2 | 2,000 | 19.6 | 110 |
| 1.6 | 1,500 | 21.5 | 100 |
| 2.3 | 1,000 | 22.9 | 95 |
| 2.6 | 900 | 24.1 | 90 |
| 2.9 | 800 | 25.4 | 85 |
| 3.2 | 700 | 26.8 | 80 |
| 3.5 | 650 | 28.3 | 75 |
| 3.8 | 600 | 30.0 | 70 |
| 4.1 | 550 | 32.0 | 65 |
| 4.5 | 500 | 34.3 | 60 |
| 4.9 | 450 | 37.0 | 55 |
| 5.5 | 400 | 40.0 | 50 |
| 5.6 | 390 | 43.5 | 45 |
| 5.8 | 380 | 48.0 | 40 |
| 5.9 | 370 | 54.0 | 35 |
| 6.1 | 360 | 61.5 | 30 |
| 6.3 | 350 | 65.0 | 28 |
| 6.4 | 340 | 70.0 | 26 |
| 6.6 | 330 | 75.0 | 24 |
| 6.8 | 320 | 80.0 | 22 |
| 7.0 | 310 | 85.0 | 20 |
| 7.3 | 300 | 93.0 | 18 |
| 7.5 | 290 | 102.0 | 16 |
| 7.8 | 280 | 112.0 | 14 |
| 8.1 | 270 | 124.0 | 12 |
| 8.4 | 260 | 140.0 | 10 |
| 8.7 | 250 | 150.0 | 9 |
| 9.1 | 240 | 160.0 | 8 |
| 9.5 | 230 | 170.0 | 7 |
| 9.9 | 220 | 183.0 | 6 |
| 10.3 | 210 | 200.0 | 5 |
| 10.9 | 200 | 218.0 | 4 |
| 11.4 | 190 | 240.0 | 3 |
| 12.0 | 180 | 265.0 | 2 |
| 12.7 | 170 | 295.0 | 1 |

By observing the definition of the cross [illegible] tube according to the instructions given, [illegible] need be no misconception concerning the point.

One great advantage in the use of Jackson turbidimeter in preference to the turbidity [illegible] that the end point in the former is appro[illegible] more sharply than in the latter, and the [illegible] the instrument is not practically a test of observer's eyesight as in the case of the turbidity rod.

## COLOR.

The field method for the determination of [illegible] is described in Circular No. 8 of the Division Hydrography, U. S. Geological Survey. It [illegible]



simple reproduction of Hazen's platinum-cobalt scale in which glass disks properly colored and rated are used instead of the actual solution in Nessler tubes. The water is placed in an aluminum tube provided with glass ends, while at the end of another tube of similar dimensions is attached a spring clasp for holding the color disks. The tubes are held at such a distance from the eye that the sides of the tubes cannot be seen, and at such an angle that both can be seen with one eye. There should be a clear white background with a strong illumination, such as a piece of white paper or the sky on a gray day. The disks are then placed one after another at the end of the tube, holding the clasp until the transmitted color is the same as that produced by the water in the other tube. The number on the disk gives the color in terms of the platinum cobalt standard.

## IRON.

The aluminum tubes designed for field deter-

FIG. 6. END SPAN OF FADES VIADUCT UNDER ERECTION.

mination of natural color, are utilized in the determination of iron.

Colorimetric methods are believed to be the simplest and best for the determination of iron in natural waters and they readily lend themselves to modification for field purposes. That which involves the use of potassium ferrocyanide, described on page 226, "Sutton's Volumetric Analysis," 9th edition, was selected as best adapted for the purposes in view. The process involves the addition of acid and potassium ferrocyanide to the water under investigation or to the residual solution of that water, thereby producing a characteristic blood red color. The depth of this color is absolutely fixed by the amount of iron in the water. It is then necessary to add to a similar mixture, made up with distilled water, such a quantity of standard iron solution as will produce in this solution exactly the same shade of red as is shown in the water under investigation. Then from the amount of standard iron solution used to produce that shade of red, the amount of iron in the water under investigation may easily be determined.

The modification of this method for field purposes consists of the uses of fixed color standards, each having been previously rated to correspond with some known equivalent of iron. The color standards used may be red glass disks, rated and used in precisely the same way as the natural color standards, or colored paper properly rated will serve as well. With the former the colored light is transmitted directly through the disk tube and the disks may be changed or combined until the color of the sample under examination is matched. Then from the rating of the disks the amount of iron may be stated. It is, however, quite expensive and difficult to procure glass of the exact shade required, especially in the lighter tints, and the process of setting them up adds materially to the cost. The paper standards are far simpler to prepare. The blood red color of the standard solutions can be accurately copied upon paper in an almost infinite variety of tints. The sheets are then bound in book form of convenient size and shape. Every alternate leaf in such a book should be a pure white. In making determinations one of the aluminum tubes is filled with the water to be tested, properly treated with acid and potassium ferrocyanide, while the other should contain distilled or colorless water. With the book lying open before the observer the tube containing the solution to be tested should be pointed toward the white leaf, while that containing the colorless water toward the colored leaf. The positions of the tubes should be such that the eye can see through both at a glance. The pages should then be turned until the color in both tubes is alike. The rating of the colored page then gives the amount of iron which was to be determined.

A sample of the clear water to be tested is poured into a 50 or 100 c. c. graduate to the 45 c. c. mark, 2 c. c. of conc. nitric acid added, and the contents thoroughly mixed in order to convert all ferrous iron present into ferric iron.

The mixing and oxidization is preferably accomplished by pouring the solution from the graduate into another vessel, such as the glass turbidimeter tube, and vice versa, at least 8 or 10 times. To the acidified solution in the graduate is now added 3 c. c. of a solution of potassium sulpho-cyanide containing 20 grms. K C N S per liter, and the liquids thoroughly mixed. The solution is now transferred to the aluminum colorimeter tube, which has a capacity of about 45 c. c. and is about 8 inches long.

Nitric acid is used in the above method instead of hydrochloric acid, commonly employed, in the first place to avoid any corrosion of the aluminum tubes. With the employment of nitric acid instead of hydrochloric acid, moreover, it was discovered that the color produced in iron solutions by the addition of sulphocyanide is somewhat deeper and does not fade as rapidly. Finally, the addition of nitric acid not only effects the required acidity of the solution, essential to the test, but obviates the need of employing potassium permanganate, in order to convert any ferrous iron present to the ferric state.

The results reached by this method of determination should be as accurate as those of the laboratory method.

## CHLORINE.

The Geological Survey uses a method for the rapid determination of chlorides which for numerous experiments already performed seems to meet the conditions in a satisfactory manner. In place of the standard solution of silver nitrate, which must be measured in a burette when applied to a water under examination, there are used tablets of silver nitrate containing a known equivalent of this reagent. These tablets are packed in tubes and carried in a leather case. This method of packing is well designed to avoid mechanical agitation of the tubes which would result in their loss of active equivalent. The tablets are held securely in place by the stoppers which are sufficiently small to be pushed through the lumen of the tube as fast as the tablets are used. This maintains a constant pressure against the tablets and prevents their agitation.

The manufacture of stable silver nitrate tablets proved to be somewhat difficult. A number of pharmaceutical experts who were engaged at various times to prepare them failed to produce a tablet which was reasonably stable. Those which are now supplied to the Survey are made by the Kremers-Urban Co., of Milwaukee, Wis., and are of superior quality.

In connection with the determination of chlorides, it is necessary to carry into the field only a small bottle of potassium chromate solution, and a glazed porcelain mortar and pestle. The tablets are dissolved in a measured quantity of water, containing a small amount of potassium chromate. The end point is indicated by the change in color in the usual way and the number of tablets of known equivalent indicates the amount of chloride in the water.

This method may be objected to by some chemists because of the fact that the results of a chlorine determination are frequently erroneous unless the titration is made upon an evaporated concentrate, representing a considerable amount of the original water. This is apparently true with waters like those of New England which contain only minute quantities of chlorine, but in the waters of the greater part of the country the chlorides are so high in amount that the error which arises from direct titration is not large enough to be of significance in industrial work.

While these tablets may be manufactured to contain almost any reasonable amount of silver nitrate, it has been found that the most convenient equivalents for general field use are those of approximately one milligram and ten milligrams of chlorine. In all special cases the strength of tablets should be adjusted to suit conditions, and it is often necessary to make use of those containing equivalent different from those generally adopted for field use. As it is practically impossible to manufacture tablets of the exact equivalent desired, it is necessary to determine the strength of each new supply and to make calculations of all field results accordingly.

Table II. shows various tests of a supply of tablets. Each tablet was made up to contain an equivalent of as near one milligram of chlorine as possible. The purposes of the tests were to determine the variation in equivalent of single tablets and the combined equivalent of tablets in sets of five and ten, the actual values in milligrams of chlorine being determined by volumetric methods.

It will be seen from the results given that the maximum variation in the equivalent of single tablets is .057 milligrams of chlorine for each tablet. Therefore considering the maximum variation shown in the single tablets and allowing for purposes of illustration that the maximum error may always be present in a determination, it would be necessary to use 18 tablets in a determination in order to reach an error of one part per million. The mean value, however, of the single tablet is thoroughly representative of all the tablets tested, the variations lying above and below the mean value equally. It will be seen further that when the tablets are used in larger quantities and the combined equivalents of such quantities are compared, that the deviations from the mean are considerably less and the maximum deviation is practically negligible. This is shown especially well in the statement of the comparison of the ten tablets. It is therefore apparent that the tablets do not vary by an appreciable amount, and that having established their equivalent by taking the mean of several determinations, such mean can be used in connection with the field determinations of chlorine in natural waters.

Table II.—Tests to Determine Variation in Silver Nitrate Tablets.

| Single Tablets. | | Five Tablets. | | | Ten Tablets. | | |
|---|---|---|---|---|---|---|---|
| Equivalent of one tablet. | Deviation from mean. | Equivalent of five tablets. | Mean equivalent of one tablet. | Deviation of one tablet from mean. | Equivalent of ten tablets. | Mean equivdlent of one tablet. | Deviation of one tablet from mean |
| .96 | — .045 | 5.060 | 1.012 | — .015 | 10.24 | 1.024 | + .0055 |
| .95 | — .055 | 5.230 | 1.046 | + .019 | 10.15 | 1.015 | — .0035 |
| 1.049 | + .044 | 5.210 | 1.042 | + .015 | 10.17 | 1.017 | — .0015 |
| 1.062 | + .057 | 5.110 | 1.022 | — .005 | 10.18 | 1.018 | — .0005 |
| ..... | ..... | 5.090 | 1.018 | — .009 | ..... | ..... | ..... |
| ..... | ..... | 5.200 | 1.040 | + .013 | ..... | ..... | ..... |
| ..... | ..... | 5.080 | 1.016 | — .011 | ..... | ..... | ..... |
| ..... | ..... | 5.110 | 1.022 | — .005 | ..... | ..... | ..... |
| Mean. | Max. Dev. | | | Max. Dev. | | | Max. Dev. |
| 1.005 | + .057 | 5.211 | 1.027 | + .019 | 10.185 | 1.018 | + .0055 |

Table III.—Tests of Silver Nitrate Tablets with Solutions of Known Equivalent.

Solution No. 1.—Chlorine 4280 Parts per Million.

| Vol. Sol. | No. of Tablets. | Value of Tablets. | Parts Chlorine Tablet Method. | Deviation From Actual Value. | Per Cent. Deviation. |
|---|---|---|---|---|---|
| 22 c. c. | 133.0 | 1.052 | 6350 | + 2070 | 48.4 |
| 5 " | 21.0 | 1.052 | 4410 | + 130 | 3.04 |
| 5 " | 21.0 | 1.052 | 4410 | + 130 | 3.04 |
| 25 " | 10.4 | 10.1 | 4200 | — 80 | 1.87 |
| 25 " | 10.0 + 3.0 | 10.1 + 1.052 | 4160 | — 120 | 2.80 |
| 50 " | 20.8 | 10.1 | 4200 | — 80 | 1.87 |
| 50 " | 20.0 + 5.0 + 1.0 | 10.1 + 1.052 + .481 | 4154 | — 126 | 2.44 |
| | | | | | 6)15.06 |
| | | | | | 2.51 Mean |

Solution No. 2.—Chlorine 12940 Parts per Million.

| Vol. Sol. | No. of Tablets. | Value of Tablets. | Parts chlorine Tablet Method. | Deviation From Actual Value. | Per Cent. Deviation. |
|---|---|---|---|---|---|
| 26 c. c. | 32.25 | 10.1 | 12510 | — 430 | 3.32 |
| 26 " | 32.0 | 10.1 | 12430 | — 510 | 3.94 |
| 15 " | 19.5 + 1.0 | 10.1 + 1.052 | 13200 | + 260 | 2.01 |
| 15 " | 18.5 + 8.0 | 10.1 + 1.052 | 13020 | + 80 | .62 |
| 5 " | 64.0 | 1.052 | 13470 | + 530 | 4.09 |
| | | | | | 5)13.98 |
| | | | | | 2.80 Mean |

Solution No. 3.—Chlorine 1372 Parts per Million.

| Vol. Sol. | No. of Tablets. | Value of Tablets. | Parts Chlorine Tablet Method. | Deviation From Actual Value. | Per Cent. Deviation. |
|---|---|---|---|---|---|
| 50 c. c. | 6.7 | 10.1 | 1353 | — 19 | 1.38 |
| 50 " | 6.0 + 7.0 | 10.1 + 1.052 | 1358 | — 14 | 1.02 |
| 50 " | 6.0 + 6.0 + 2.0 | 10.1 + 1.052 + .481 | 1358 | — 14 | 1.02 |
| 20 " | 26.0 + 1.0 | 1.052 + .481 | 1392 | + 20 | 1.46 |
| 5 " | 6.0 + 1.0 + 2.4 | 1.052 + .481 + .253 | 1480 | + 108 | 7.39 |
| | | | | | 5)12.27 |
| | | | | | 2.45 Mean |

PRACTICAL TESTS WITH TABLET METHOD.—Three chloride solutions were made up at random which, when tested by precise methods were found to contain 4,280, 12,940 and 1,372 parts of chlorine per million, respectively. These solutions were titrated with tablets, and the end points reached in the same manner as that used in the field. The results are set forth in Table III.

The first result in the table above set forth is so radically wrong that it is inserted to illustrate a condition which must always be avoided in the use of this method; viz., the use of a large number of tablets of low equivalent. It will be noted upon examination that a considerable amount of strong chloride solution was used with tablets of low equivalent; i. e., 1.052 mg. of Cl. This made it necessary to use 133 tablets to reach the end point. It will be noted, however, that 25 and 50 c. c. of the same solution are titrated with the tablets and only a small error occurs, when the tablets of a larger equivalent, 10.1 mg. of chlorine, are used. On the whole, the results shown in above table are very satisfactory, the error involved in the determinations averaging about 2.5% to 3%, which is well within the limits of field work. Indeed, when the method was designed it was believed that an error of 5% would be as close as could be expected.

A very simple way of testing for small amounts of chlorine is afforded by cutting tablets into quarters with a jackknife. Only ordinary care need be used and the quarters may then be taken for analysis without extreme regard to the selection of large or small pieces.

ESTIMATION OF CHLORINE.

100 c. c. of the water to be tested is measured into a glazed porcelain mortar (4 ins. diameter) and 5 drops of potassium chromate added.

One silver nitrate tablet is then cut into quarters, using ordinary care to get the quarters equal. Whole tablets are added to the water till near the end point when quarter tablets are used. The end point is the appearance of the red color of potassium chromate.

No. of tablets used multiplied by equivalent of 1 tablet, multiplied by 10 = mg. per liter of chlorine.

Allow 1 mg. for end reaction.

For example:

2¾ tablets used = 27.5 mg. per liter — 1 mg.
= 26.5 mg. Cl. per liter.

TOTAL HARDNESS.

Tablets of pure sodium oleate are used for this determination. They are superior to the soap solution in all respects save that of refined accuracy. The limit of accuracy in the determination with tablets is 2.5 parts per million. This, as every chemist knows, is sufficiently close for all purposes for which the soap test is used. The tablets are made up only with the imported, refined oleate. The Geological Survey uses three equivalents denoted as "F," "H" and "Q," or corresponding to 1 mg., 0.5 mg. and 0.25 mg. of $CaCO_3$, respectively.

In using these tablets, 100 c. c. of the water to be tested are placed in a specially designed bottle (Emil Greiner) with a heavy, hemispherical bottom. Tablets are then added, one at a time, and dissolved in the water. This process is greatly hastened by trituration of the tablets in the bottle, with a blunt glass rod. After each tablet is dissolved the bottle should be shaken and laid upon its side and the determination conducted in precisely the same manner as that prescribed in the case of the soap solution. From the number of tablets used and their equivalent, the hardness may be determined.

The facility with which this determination may be carried on is largely determined by practice. When first attempted, it seems awkward, but after a few trials the operator finds it quite readily performed. The proper way is to start with the "F" tablets until near the end point, then apply the "H" and finally the "Q" tablets. This, of course, may become a method of "trial and error," but the skilled field man will seldom add tablets beyond the end point. The appearance of the lather at various stages is characteristic, and affords a guide for the operator.

It is customary to distinguish between temporary and permanent hardness. Temporary hardness is due to the carbonates (and bicarbonates) of calcium and magnesium. Temporary and permanent hardness are often expressed as alkalinity and incrusting constituents respectively, and it is common to see even in analytical reports of well informed chemists, the expression, "alkalinity equivalent to temporary hardness." This expression is misleading. It is approximately correct when the waters of New England and certain other portions of the country are referred to, but as a general statement concerning the majority of waters, nothing could be more inaccurate. There are abundant instances in which waters are alkaline to an extraordinary degree, and yet are widely known as soft waters and give little or no reaction with the soap test. The alkalinity in such cases is due to the carbonates of sodium and potassium which, while th... part a truly alkaline reaction, have no ha... effect.

TABLE IV.—Comparative Determinations of Alkalinity in Carbonate Solutions with Standard Sulphuric Acid and Sodium Acid Tablets.

Carbonate Solution No. 1—Alkalinity 5,764 parts per million in terms of calcium carbonate.

| Amount of Solution. | Number of Tablets. | Parts per Million. | Deviation in Parts per Million. | Per Cent. Deviation. |
|---|---|---|---|---|
| 1.9 c. c. | 5 | 5225 | — 539 | 9.3 |
| 3.5 " | 10 | 5674 | — 90 | 1.56 |
| 7.0 " | 20 | 5674 | — 90 | 1.56 |
| 11.0 " | 32 | 5726 | — 38 | .66 |
| 10.5 " | 30 | | | |
| 17.5 " | 50 | 5674 | — 90 | 1.56 |
| 46.5 " | 135 | 5767 | × 3 | .05 |

Carbonate Solution No. 2—Alkalinity 2,312 parts per million in terms of calcium carbonate.

| Amount of Solution. | Number of Tablets. | Parts per Million. | Deviation in Parts per Million. | Per Cent. Deviation. |
|---|---|---|---|---|
| 4.5 c. c. | 5 | 2207 | — 105 | 4.55 |
| 10.0 " | 12 | 2383 | + 71 | 3.1 |
| 15.0 " | 18 | | | |
| 21.0 " | 25 | 2384 | + 72 | 3.1 |
| 19.0 " | 23 | | | |
| 25.5 " | 30 | 2359 | + 47 | 2.0 |
| 25.0 " | 30 | | | |
| 51.0 " | 60 | 2328 | + 14 | 0.61 |
| 50.5 " | 59 | | | |

ALKALINITY.

The determination of alkalinity or carb... is a simple volumetric process. It requires ... a standard solution of an acid, preferably a m... eral acid, with accurate means for measuring ... same, and a proper indicator solution. Th... jections already cited to the carrying of stan... solutions and burettes in the field led to an... tempt to adopt an acid which could be prese... in tablet form. Many organic acids were t... but it was found that they were either too w... to afford a definite end point or else were of ... deliquescent a character that they could not ... made to form stable tablets. It was finally d... cided to adopt the use of sodium acid sulpha... Tablets made from this reagent are easily reg... lated in equivalent and of an extremely stabl... nature. The results which can be procured through their use are very satisfactory. The tests of Table IV. are submitted to show the deviations which may arise in successive tablets or successive sets of tablets. The tablets used were marked, "Lot 175, Sodium Acid Sulphate equivalent to 1.995 mg. Calcium Carbonate." These tablets had been in stock for several months, and had received some rough handling and were in poor condition. In fact, they represented the most unfavorable conditions that might be supposed to occur in connection with the field use of tablets and the variations which are shown may be accepted as the extreme variations which are likely to occur in common use.

In testing and standardizing the sodium acid sulphate tablets, normal solutions of sulphuric acid and sodium carbonate were used. Tests were made as follows:

Solutions of unknown strength of sodium carbonate were made up and the alkalinity determined volumetrically with standard sulphuric acid solution. Following this, determinations of the same unknown solutions were made with the tablets. Varying amounts of the solution were used with a corresponding variation in the number of tablets.

The figures of Table IV. show that when a large number of tablets are used to determine alkalinity, the results are more nearly correct than when a few are used. This is especially noticeable in the first entries in the two tables above set forth where a small amount of the alkaline solution is used and requires only five tablets. The error in each of these cases is larger than is permissible even in field work. In the remainder of the entries, however, the variation is not sufficiently great to be appreciable, especially in the weaker carbonate solutions where it is shown that the use of a larger number of tablets involves a minimum error. This suggests that in connection with the field determination of carbonates it is advisable wherever waters of a low alkalinity are tested to use a large amount of the water in order that a large number of tablets can be used to neutralize the alkalinity, and thereby avoid the error arising from the variation which occurs in the single tablets.

ESTIMATION OF ALKALINITY.

Measure 100 c. c. of water to be tested into a glazed porcelain mortar (4-in. diameter). Add 2 drops methyl orange indicator. Add $NaHSO_4$ tablets till an acid reaction is reached. Then add the water to be tested till an alkaline reaction is shown. Measure the liquid in the mortar and add 1 c. c. for the wetted interior of the dish.

$$\frac{1000}{W} nA = \text{mg. per liter of } CaCO_3.$$

When W = No. c c. of water used.
n = No. of tablets used.
A = Value of 1 tablet in mg. of $CaCO_3$.

Each tube of tablets is marked with its value in equivalent of $CaCO_3$.

NORMAL AND ACID CARBONATES.

It is important for many engineering purposes to ascertain the proportion of normal and acid carbonate in a water. It is well known that the alkaline-earth metals such as calcium and magnesium, which form soft scale in boilers and are troublesome or damaging in many other industrial lines, are in aqueous solution in the form ...

bicarbonate. The alkalies, sodium and potassium, are soluble, both as normal and acid carbonates, and occur in both forms in certain waters such as the highly alkaline waters of the arid regions. In general practice, however, and especially with the waters occurring east of the Rocky Mountains, no important errors will arise if it be considered that all the bicarbonates are those of Calcium and Magnesium, and all normal carbonates those of Sodium and Potassium. There is usually only a comparatively small amount of alkali salts in such waters, and in the event that all or a part of it were in solution as bicarbonate, the interpretation placed upon the results would not lead to appreciable error.

The field method for the determination of normal and acid carbonates is a modification of that first suggested by Winkler and more recently developed by Frank K. Cameron, U. S. Department of Agriculture. The method depends upon the fact that carbonic acid ($CO_3$) or hydrogen carbonic acid ($HCO_3$) is a stronger acid than phenolphthalein, but weaker than methyl-orange. The water under examination is titrated with a standard equivalent of sodium acid sulphate, this reagent being used for field work in the Geological Survey in the form of tablets which are the same as those described above for the determination of total carbonates.

To make the determination, measure a convenient quantity of the water to be tested into a porcelain mortar and add 4 drops of phenolphthalein. Triturate the standard $NaHSO_4$ tablets in the mortar one at a time until the color disappears. Note the number of tablets used and then add 4 drops of methyl orange. Continue the titration with the tablets until the orange color of the solution changes to a faint pink, then note the total number of tablets used in both titrations. The equivalent of the sodium acid sulphate tablets is given in terms of calcium carbonate. Therefore the amount of bicarbonates in the water may be calculated directly from this valuation. In order to calculate the normal carbonates as $Na_2CO_3$, it would be necessary to multiply the valuation of the sodium sulphate tablets given by 1.05, the conversion factor of $CaCO_3$ to $Na_2CO_3$. For computation of the results of the titration above described the following symbols are given:

A = equivalent of $NaHSO_4$ tablets in terms of milligrams of $CaCO_3$.

B = equivalent of $NaHSO_4$ tablets in terms of milligrams of $Na_2CO_3$.

The conversion factor being 1.05, we have,

$$A = \frac{B}{1.05} \text{ or } B = 1.05A.$$

n = number of tablets used to reach first or phenolphthalein end point.

N = number of tablets used to reach second or methyl orange end point.

W = amount in c. c. of water tested.

Then for the determination of normal carbonates we have the formula $\frac{2000nb}{W}$, and for the determination of bicarbonates $\frac{1000(N-2n)A}{W}$.

The results of the two above equations will be the expression of parts per million.

A discussion of these formulas is included in a Water Supply and Irrigation Paper entitled, "Field Methods of Water Assay," which will be ready for distribution about one year from date.

TABLE V.—For Converting Readings in Depths by the Turbidimeter into Parts per Million or Grains per Gallon of Sulphate.

| Reading in centimeters. | Pts. per mil. $SO_3$. | Grains, per U. S. gal. $SO_3$. | Reading in centimeters. | Pts. per mil. $SO_4$. | Grains, per U. S. gal., $SO_3$ |
|---|---|---|---|---|---|
| 1.0 | 520 | 30.5 | 7.7 | 74 | 4.3 |
| 1.1 | 480 | 28.0 | 7.8 | 73 | 4.3 |
| 1.2 | 440 | 25.5 | 7.9 | 72 | 4.2 |
| 1.3 | 410 | 24.0 | 8.0 | 71 | 4.2 |
| 1.4 | 385 | 22.5 | 8.1 | 70 | 4.1 |
| 1.5 | 360 | 21.0 | 8.2 | 69 | 4.0 |
| 1.6 | 340 | 20.0 | 8.3 | 68 | 4.0 |
| 1.7 | 320 | 18.5 | .. | .. | .. |
| 1.8 | 300 | 17.5 | 8.5 | 67 | 3.9 |
| 1.9 | 285 | 16.5 | 8.6 | 66 | 3.9 |
| 2.0 | 275 | 16.0 | 8.7 | 65 | 3.8 |
| 2.1 | 260 | 15.0 | 8.8 | 64 | 3.8 |
| 2.2 | 250 | 14.5 | .. | .. | .. |
| 2.3 | 240 | 14.0 | 9.0 | 63 | 3.7 |
| 2.4 | 230 | 13.5 | 9.1 | 62 | 3.7 |
| 2.5 | 220 | 13.0 | 9.3 | 61 | 3.6 |
| 2.6 | 215 | 12.5 | 9.5 | 60 | 3.6 |
| 2.7 | 205 | 12.0 | 9.7 | 59 | 3.5 |
| 2.8 | 200 | 11.7 | 9.8 | 58 | 3.4 |
| 2.9 | 190 | 11.1 | 10.0 | 57 | 3.3 |
| 3.0 | 185 | 10.8 | 10.2 | 56 | 3.3 |
| 3.1 | 180 | 10.5 | 10.4 | 55 | 3.2 |
| 3.2 | 175 | 10.2 | 10.6 | 54 | 3.2 |
| 3.3 | 170 | 9.9 | 10.8 | 53 | 3.1 |
| 3.4 | 165 | 9.6 | 11.0 | 52 | 3.1 |
| 3.5 | 160 | 9.4 | 11.2 | 51 | 3.0 |
| 3.6 | 155 | 9.1 | 11.4 | 50 | 3.0 |
| 3.7 | 150 | 8.8 | 11,6 | 49 | 2.9 |
| 3.8 | 147 | 8.6 | 11.8 | 48 | 2.8 |
| 3.9 | 144 | 8.4 | 12.0 | 47 | 2.7 |
| 4.0 | 140 | 8.2 | 12.4 | 46 | 2.7 |
| 4.1 | 137 | 8.0 | 12.6 | 45 | 2.6 |
| 4.2 | 133 | 7.8 | 12.8 | 44 | 2.6 |
| 4.3 | 131 | 7.7 | 13.0 | 43 | 2.5 |
| 4.4 | 128 | 7.5 | 13.5 | 42 | 2.5 |
| 4.5 | 125 | 7.3 | 14.0 | 41 | 2.4 |
| 4.6 | 122 | 7.1 | 14.5 | 39 | 2.3 |
| 4.7 | 119 | 7.0 | 15.0 | 38 | 2.3 |
| 4.8 | 117 | 6.8 | 15.5 | 37 | 2.2 |
| 4.9 | 115 | 6.7 | 16.0 | 36 | 2.1 |
| 5.0 | 113 | 6.6 | 16.5 | 35 | 2.0 |
| 5.1 | 110 | 6.4 | 17.0 | 34 | 2.0 |
| 5.2 | 108 | 6.3 | 17.5 | 33 | 1.9 |
| 5.3 | 106 | 6.2 | 18.0 | 32 | 1.9 |
| 5.4 | 104 | 6.0 | 18.5 | 31 | 1.8 |
| 5.5 | 103 | 6.0 | 19.0 | 30 | 1.8 |
| 5.6 | 101 | 5.9 | 20.0 | 29 | 1.7 |
| 5.7 | 99 | 5.8 | 21.0 | 28 | 1.7 |
| 5.8 | 97 | 5.7 | 22.0 | 27 | 1.6 |
| 5.9 | 96 | 5.6 | 22.5 | 26 | 1.6 |
| 6.0 | 94 | 5.5 | 23.0 | 25 | 1.5 |
| 6.1 | 93 | 5.4 | 24.0 | 24 | 1.4 |
| 6.2 | 91 | 5.3 | 25.0 | 23 | 1.3 |
| 6.3 | 90 | 5.2 | 26.5 | 22 | 1.3 |
| 6.4 | 88 | 5.1 | 28.0 | 21 | 1.2 |
| 6.5 | 87 | 5.1 | 29.0 | 20 | 1.2 |
| 6.6 | 86 | 5.0 | 31.0 | 19 | 1.1 |
| 6.7 | 84 | 4.9 | 33.0 | 18 | 1.1 |
| 6.8 | 83 | 4.9 | 35.0 | 17 | 1.0 |
| 6.9 | 82 | 4.8 | 37.5 | 16 | 1.0 |
| 7.0 | 81 | 4.8 | 40.0 | 15 | 0.9 |
| 7.1 | 80 | 4.7 | 43.0 | 14 | 0.9 |
| 7.2 | 79 | 4.7 | 46.5 | 13 | 0.8 |
| 7.3 | 78 | 4.6 | 50.0 | 12 | 0.7 |
| 7.4 | 77 | 4.5 | 55.5 | 11 | 0.6 |
| 7.5 | 76 | 4.4 | 62.0 | 10 | 0.6 |
| 7.6 | 75 | 4.4 | 68.0 | 9 | 0.5 |

## SULPHATES.

Water generally contains either one or more of the sulphates of sodium, potassium, calcium, magnesium and iron. If present in minute amounts, the effect of any or all of them is negligible, but if they appear in large proportions they do damage in every branch of science or industry in which it is necessary to use water. Calcium and magnesium and iron sulphates damage boilers, textiles, soaps, malt liquors, paper and many other manufactured products, while they render water undesirable for domestic purposes. The sulphates of sodium and potassium are troublesome in boilers and damage crops when water containing large amounts is used for irrigation. A knowledge of the amount of sulphates in a water is of great importance.

The determination of sulphates, as it is usually performed in a laboratory, is a slow, laborious and expensive process. A field method has, however, been devised by which the sulphates can be determined in a few minutes and with a degree of accuracy sufficient for all practical purposes. The determination involves the use of the Jackson turbidimeter, described above. In the following paragraphs the determination of sulphates is described by the originator, Mr. D. D. Jackson.

TABLE VI.—For Estimation of Calcium in Water in Parts per Million with Jackson Turbidimeter.

| Depth. | Calcium equivalent. | Depth. | Calcium equivalent. | Depth. | Calcium equivalent. |
|---|---|---|---|---|---|
| 1.0 | 1,150 | 5.2 | 116 | 9.4 | 57 |
| 1.1 | 1,000 | 5.3 | 113 | 9.5 | 56 |
| 1.2 | 890 | 5.4 | 110 | 9.6 | 55 |
| 1.3 | 795 | 5.5 | 107 | 9.7 | 55 |
| 1.4 | 715 | 5.6 | 105 | 9.8 | 54 |
| 1.5 | 650 | 5.7 | 102 | 9.9 | 54 |
| 1.6 | 595 | 5.8 | 100 | 10.0 | 53 |
| 1.7 | 550 | 5.9 | 98 | 10.2 | 52 |
| 1.8 | 505 | 6.0 | 96 | 10.4 | 51 |
| 1.9 | 470 | 6.1 | 94 | 10.6 | 50 |
| 2.0 | 435 | 6.2 | 92 | 10.8 | 49 |
| 2.1 | 410 | 6.3 | 90 | 11.0 | 48 |
| 2.2 | 380 | 6.4 | 88 | 11.2 | 47 |
| 2.3 | 360 | 6.5 | 87 | 11.4 | 46 |
| 2.4 | 340 | 6.6 | 85 | 11.7 | 45 |
| 2.5 | 320 | 6.7 | 84 | 11.9 | 44 |
| 2.6 | 305 | 6.8 | 82 | 12.2 | 43 |
| 2.7 | 288 | 6.9 | 81 | 12.4 | 42 |
| 2.8 | 274 | 7.0 | 80 | 12.7 | 41 |
| 2.9 | 261 | 7.1 | 78 | 13.0 | 40 |
| 3.0 | 248 | 7.2 | 77 | 13.3 | 39 |
| 3.1 | 238 | 7.3 | 76 | 13.7 | 38 |
| 3.2 | 228 | 7.4 | 74 | 14.0 | 37 |
| 3.3 | 218 | 7.5 | 73 | 14.4 | 36 |
| 3.4 | 209 | 7.6 | 72 | 14.8 | 35 |
| 3.5 | 200 | 7.7 | 71 | 15.3 | 34 |
| 3.6 | 194 | 7.8 | 70 | 15.7 | 33 |
| 3.7 | 186 | 7.9 | 69 | 16.2 | 32 |
| 3.8 | 179 | 8.0 | 68 | 16.7 | 31 |
| 3.9 | 173 | 8.1 | 67 | 17.3 | 30 |
| 4.0 | 167 | 8.2 | 66 | 17.9 | 29 |
| 4.1 | 162 | 8.3 | 65 | 18.5 | 28 |
| 4.2 | 156 | 8.4 | 64 | 19.2 | 27 |
| 4.3 | 151 | 8.5 | 64 | 20.0 | 26 |
| 4.4 | 146 | 8.6 | 63 | 20.8 | 25 |
| 4.5 | 142 | 8.7 | 62 | 21.7 | 24 |
| 4.6 | 137 | 8.8 | 61 | 22.7 | 23 |
| 4.7 | 133 | 8.9 | 60 | 23.8 | 22 |
| 4.8 | 130 | 9.0 | 60 | 24.0 | 21 |
| 4.9 | 126 | 9.1 | 59 | 25.2 | 20 |
| 5.0 | 123 | 9.2 | 58 | .... | .. |
| 5.1 | 119 | 9.3 | 57 | .... | .. |

Jackson's turbidimeter is used to determine calcium under conditions practically the same as those described for sulphates. The water to be tested is made very slightly ammoniacal, and a small quantity of ammonium oxalate crystals is added. The calcium is precipitated as calcium oxalate. The turbidity produced thereby is read and the equivalent in calcium determined according to Table VI.

To 100 c. c. of water to be tested add 1 c. c. of hydrochloric acid (1-1) and 1 gram of solid barium chloride crystals. If the amount of sulphate is low, 200 or 300 c. c. of water must be treated in order to fill the longer tube employed. In this case add 1 c. c. of acid and 1 gram of barium chloride for each 100 c. c. of water taken.

Allow the mixture to stand for ten minutes with frequent shaking. It is best to employ a bottle for this purpose. Treating the water in the cold with solid barium chloride causes the barium sulphate to be precipitated in a finely divided state, and the turbidity produced may then be read either by the candle or by the electric turbidimeter.

In the lower part of the tube the end point is taken when the hazy cross of light disappears. This is a higher reading than the point where the sharp cross disappears. Higher up in the tube there is no hazy cross of light, and the end point is the disappearance of the sharp cross of light. When this point is obtained, remove the glass tube and find the depth of the liquid (using the bottom of the meniscus in reading). Refer this reading to the accompanying table to obtain the parts per million or grains per gallon of sulphate present.

The readings of these instruments are only to a very slight extent affected by the amount of light used, so that a fairly wide variation in this respect gives little or no error in the result. This is also true with variations in the color of different natural waters. The reason for this lies in the fact that the end point is not to any great extent dependent upon the amount of light cut out, but to the complete covering up of the image of light by the particles in suspension. It is surprising to find that the interposition of disks if of highly colored glass produce little or no effect upon the end point.

## CALCIUM.

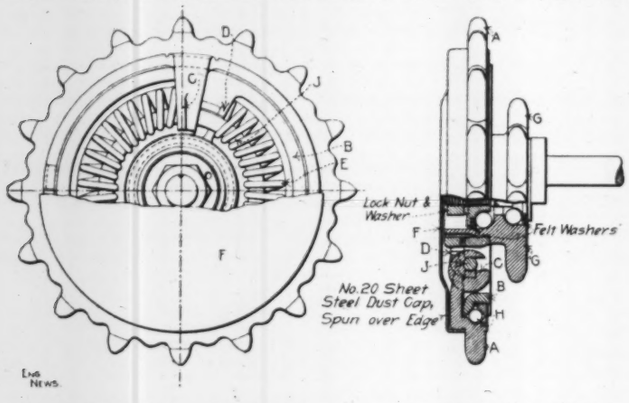
## TWO NEW POWER TRANSMISSION DEVICES.

The Pope spring sprocket is an "elastic-transmission" device designed particularly for motor bicycles, which vehicles are universally operated by gasoline engines. Its purpose is to equalize the sharp impulses of the working explosions before the shocks can reach the driving wheel. A very neat mechanical construction is used in carrying out this purpose. The spring sprocket is similar in principle of construction to the "flexible" couplings which were formerly much used in driving shafts for dynamos. The detail arrangement, however, is elaborated in a novel manner, as will be seen from the drawings shown herewith.

The device is shown in section in Fig. 1, which may be explained in brief as follows: The inner or small sprocket-wheel G carries the chain leading back to the sprocket on the hub of the rear or driving wheel of the motor bicycle. The outer or large sprocket-wheel A carries the chain leading from a sprocket-wheel on the engine shaft. The two sprockets A and G can rotate relative to each other, to the extent of part of a revolution, but they are firmly connected in a radial direction. The inner sprocket carries a ringlike frame B, which with the inner periphery of the large sprocket forms a ball-race H. Sixteen 7-32-in. balls with 9-16-in. separators run in this race. The relative rotation of the two sprockets is counteracted by two helical springs, E, each sprung to the form of a half circle, which are confined between radial lugs, C, on the outer sprocket, and D on the carrying frame of the inner sprocket. A steel ring, J, passing through the springs and through both pairs of lugs confines the springs against outward buckling as they become compressed. A sheet-steel dust-cover, F, which is spun over four projections on the face of the outer sprocket, closes one side completely.

The complete device is mounted on a ¼-in. eccentric stud on the end of a 7-16-in. shaft seated in bearings in the vehicle frame. The stud has an eccentricity of 5-16-in. As the chains on the

sprockets A and G lead off in opposite directions, any adjustment of one chain would, if the spring-sprocket were mounted on a fixed shaft, require a corresponding adjustment of the other chain, or else would throw the unbalanced pull on the spring-sprocket bearings. The eccentric mounting avoids this, as the tightening of only one chain serves to tighten both, and leaves the




Sectional Side Elevation. Sectional End Elevation.

FIG. 1. SECTIONAL VIEWS OF POPE SPRING-SPROCKET.

spring sprocket, as well as its shaft, without load.

Fig. 2 shows detail drawings of the principal parts of the device, and Fig. 3 gives a photographic view with the dust-guard F removed. Of the service of this sprocket the makers, the Pope Manufacturing Co., of Hartford, Conn., say the following:

The two methods in commercial use at the present time for the transmission of power on a motor cycle from the motor to the rear wheel are the belt drive and the chain drive. The belt drive was probably the earliest device in use, but has always been more or less unsatisfactory, its chief objection being that it slips under the explosions or impulses of the motor, which indicates a heavy loss of power. The rider of a belt-driven machine of sufficient power to carry him over country roads necessitating much hill-climbing, will be troubled with the burning of his belt due to constant slipping and consequent generation of friction and heat. Furthermore, the rider of a belt driven motor bicycle will be chagrined to find that when he attempts to climb a severe grade he will be obliged to assist with his pedals and at the same time hear the regular working of his engine which possesses ample power to convey him up the hill unaided were this slipping of belt eradicated. Experience has marked all these statements to be facts and they are supported by the evidence of hundreds of motor bicycle riders.

The objections to the chain are that it transmits the impulse and vibrations of the engine to the rider, which causes considerable discomfort and also in the course of time pulls the chain to pieces. With the old form of construction there undoubtedly was some truth in this argument. When this company commenced to build motor cycles a careful canvass of both sides of the transmission question was made, with the result that we finally decided on a chain drive as the least of the two evils and as the best of the then existing forms of power transmission for this type of vehicle. Over a year ago by constant experimenting we perfected a special device known as the Pope (patented) Spring Sprocket. This is placed intermediately between the motor and rear wheel, and absolutely prevents all jerks and throbs of the engine from being transmitted to the rear wheel; these are absorbed, allowing the power to be received by the rear wheel with as smooth and even tension as the rear wheel of a pedal driven bicycle, and this even when running at a slow speed.

Our machine has none of the troubles of a belt-driven motor cycle or a chain-driven machine of the ordinary type. We have never yet received a complaint of a broken chain when used in connection with our spring sprocket. The action permitted by the springs is about 1¼ ins. on the circumference of the spring. It will be readily seen that since the radius of the rear wheel sprocket is so much less than the radius of the driving wheel this proportion of relief is vastly increased before the drive finally terminates at the surface of the tire, the result being a beautifully smooth action which compares closely with the ideal motion of an electric vehicle. The parts are strongly made, and under severe test have proven amply durable. When once applied to a machine they add no complications.

We consider our spring sprocket to be a true solution of the motor bicycle power transmission problem. It includes the feature of a positive drive and at all times enables a rider to operate a large powerful machine at a low rate of speed without any disagreeable thumping or jerking, either at the start or on hills when the motor is laboring hard.

A novelty in variable-speed gearing has been brought out by Johnson & Phillips of London, England, under the name of Newman Variable-Speed Gear. Its action is rather intricate, but may be understood from the accompanying diagrammatic section Fig. 4 if the following explanation is closely followed.

The driving shaft and the driven shaft are in line, and are central to the group of gears shown. The pinion G is fixed on the driven shaft, which extends out, rearward. The driving shaft, carrying the eccentric pin A, is in front of pinion G, and is not connected with the pinion. The eccentric pin A is linked by four connecting rods, B, to crank pins, C, on the four gears, E, which are grouped around and in mesh with the driven pinion G. The gears E are rotatable on pins set in the fixed case, K. Each gear, E, is composed of a central clutch block, D, and an external ring, F, the latter bearing the gear teeth on its outer periphery. The clutch block, D, has a number of recesses on its outer face, the bottom of the recesses being inclined to a circle concentric with the gear ring. Small rollers placed in these recesses form the gripping contacts. When the clutch block is turned in clockwise direction, the rollers come to bearing between the clutch block and the gear ring, locking the two together so that the gear ring must turn with the clutch block. When the clutch block moves anti-clockwise, or when the clockwise motion of the gear ring is faster than that of the clutch block, then the rollers are released.

The relation between the radial distances of the eccentric pin A and the pins C is such that the revolution of A causes the pins C to describe arcs back and forth. Therefore, the [illegible] will also describe oscillatory alt[illegible]. During the clockwise part of t[illegible] one clutch block, that block will [illegible] to grip and turn its gear ring. [illegible] gear ring also the pinion. E[illegible] clutch blocks will have different s[illegible] instant. It will also be clear that t[illegible] having the most rapid forward m[illegible] its gear ring and will turn the pi[illegible] three gear rings will then be turn[illegible]

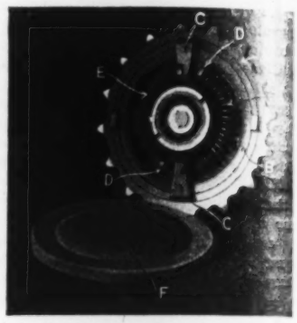



Fig. 3. View of Pope Spring-Sprocket, with Dust-Guard Removed.

sponding speed, which is faster than that of their clutch blocks. These three gear rings will continue to over-travel until one of the corresponding clutch blocks has increased its speed to equal that of the gear ring; this block will then take up the driving, while the other three run idle. In this way the four gears take turn in driving, and the pinion G is driven continuously at almost constant speed.

The speed of the driven shaft, for given speed of driving shaft, will depend directly upon the throw of the eccentric pin A. If this pin is at the center of the driving shaft, i. e., if it has zero eccentricity, then the driven shaft will not be turned, since the connecting rods and clutch blocks all remain at rest. As the pin A is shifted outward from the center, the motion imparted to the clutch blocks during each revolution of the driving shaft increases, and hence the speed of the driven shaft increases. Changing speed, therefore, is accomplished by simply shifting the eccentric pin A radially inward or outward. The company's published matter says: "Different methods are used for varying and controlling the throw of the crank or eccentric, depending on the purpose for which the gearing is intended to be used."

The Newman Variable-Speed Gear is primarily intended for driving motor vehicles. In this service it gives a continuous range of speeds, from zero to maximum, with no difficulty or danger in changing. It is also recommended for use in machine tools, textile machinery, printing presses, hoists, etc., etc. It is made in all sizes and to suit all requirements.

An important property of this gear is that it does not reverse. The driven shaft is turned in forward direction whether the driving shaft runs

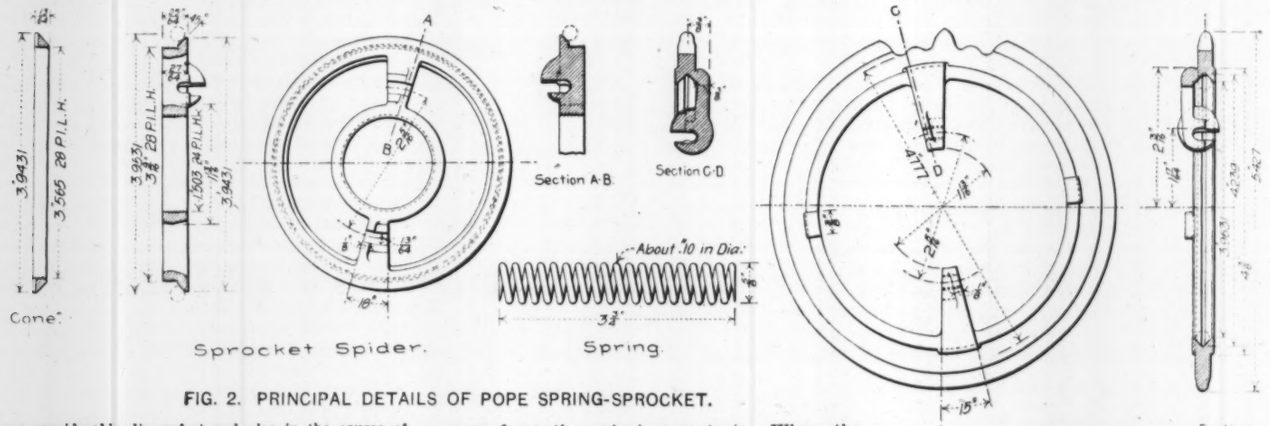



FIG. 2. PRINCIPAL DETAILS OF POPE SPRING-SPROCKET.

forward or backward. When reversing is a requirement, it is necessary to provide independent means for reversing, as, for example, a set of reversing gears with jaw or friction clutches, or the like.

## THE MEASUREMENT OF LOW ARTESIAN HEADS.*

By Myron L. Fuller.†

One of the first points an engineer or geologist is called upon to determine in his investigations of ground waters is the head or height to which the water will rise. When the catchment area is known a very rough estimate of the head can be made from the knowledge of the elevation of the well as compared with that of the outcrop of the

Fig. 4. Diagram of Construction of Newman Variable-Speed Gear.

water-bearing bed. Other factors, however, especially the size of the pores of the rock through which the water passes and the amount and points of leakage, enter into the problem of the height of head. The volume and velocity of flow, which, under certain ideal conditions, afford a basis for calculating the head, likewise commonly fail because of a lack of definite knowledge of one of the leading controlling factors; namely, the exact texture of the water-bearing material.‡ The head which in a porous material will give a large volume with considerable velocity, may in a very fine grained material, owing to its resistance to the passage of water, give only a small drizzle. In most cases the exact character of the water-bearing horizon is not known, and even where known the flow may be dependent not on the nature of the immediate material at the well, but on the average character of material which the water has penetrated in its passage from its

Fig. 5. View of Complete Newman Variable-Speed Gear.

source. This is even more rarely known than the character of the water-shed at the well.

It being, therefore, commonly impossible to accurately calculate the head, either from a knowledge of the catchment area, water-bed, etc., or from the volume or velocity of flow, it becomes necessary to determine the height to which water will rise by actual measurement of the wells in the locality which may be under investigation or in adjacent regions. This has often been done in the case of wells of high head in the more important artesian districts, but because of the cumbersome character of ordinary gages, which require not only much material in the form of joints, pipes, etc., but which also take considerable time and some skill for their application, they have been rarely used on the small wells of low head such as those which occur at many points in the drift throughout Michigan, Wisconsin, and Minnesota, where the pressure commonly ranges from 1 to 20 lbs.

The ordinary steam gage is about 5 ins. in diameter, several inches thick and weighs several pounds, and, as pointed out, considerable plumbing work has commonly been required in connecting it to the well. The writer has sought for some time to replace these large gages by one which should be of small size and capable of being instantly applied. A low-priced gage, which can be carried in the vest pocket, which can be applied to ordinary pipes and read in a second's time, and which will measure heads up to 50 lbs., or about 100 ft., has now been found.

A Small, Handy Gage for Taking Artesian Well Pressures.

The gage fulfilling these requirements is manufactured by C. Cretors & Co., of Chicago, being primarily intended for use in connection with the boilers of certain types of peanut-roasting apparatus. It is 2 ins. in diameter, or about that of a gentleman's watch, and is 1 in. in thickness. The type commonly used is nickel plated, and sells for $2.25, but a plain iron gage can be obtained at about $1.50. The dial, which is protected by a thick beveled crystal, is graduated to pounds and reads up to 50, each fifth pound being marked by figures. Into the stem of the gage a small ⅜-in. metal tube, about an inch in length, is screwed and over this is stretched and wired a rubber tube which opens out into a broad flange 2 ins. or more in diameter. (See Fig. 1.) This peculiar tube, though appearing at first sight of a character difficult to obtain, may nevertheless be secured at any drug store and is made simply by cutting through the middle of the bulb of a large-sized syringe.

In the case of small wells, such as those for which the apparatus was devised, the diameter of the pipe from which the flow issues is commonly from ½ to 1 in., and will rarely exceed 2 ins. In applying the apparatus take the gage in the right hand and at the same time slip the open half of the rubber bulb over the end of the pipe and hold it firmly so that no leakage takes place. With pressures within the limits of the gage this can be done without difficulty and the pressure read immediately from the face of the gage, and the head determined from the accompanying table:

To determine the head equivalent to a given pressure, say, of 17 lbs., start at 1 in the column on the left and follow across to the right to the column headed 7, where will be found the figures 39.2, which is the number of feet to which the water will rise. If the pressure is under 10 lbs., the head will be found in the first horizontal line.

## REINFORCED CONCRETE WAREHOUSE FOR NORTHWEST KNITTING CO., MINNEAPOLIS, MINN.

Several novelties in reinforced concrete construction are exemplified in the building illustrated in the accompanying drawings. This building is 63 ft. 1 in. × 184 ft. 6 ins. in plan and has three floors and a basement. It was designed to carry a safe load of 500 lbs. per sq. ft. of floor and also to have two stories added to its height in case future demands necessitated this additional room. Some of the novel features are: the unit reinforcing frames for columns; the use of a peripheral netting for beams and columns in addition to the rod reinforcement, the use of unstiffened slab floors resting on the main girders; the treating of the beams as continuous over supports in their computations, and the use of an exceptionally rich and wet concrete. The character of these novelties and the reasons for introducing them are briefly explained in the following paragraphs from information furnished by the engineer of the building, Mr. C. A. P. Turner, M. Am. Soc. C. E., of Minneapolis, Minn.

The general structural details of the building are shown by the drawings of Fig. 1. The building is divided by three longitudinal rows of interior columns and two rows of wall pilasters into rectangular bays. Of the transverse bays two at the middle have spans of 15 ft. and two at the sides spans of 16 ft. 1½ ins., and of the eleven longitudinal bays two at the ends have spans of 17 ft. and 17 ft. 6 ins., and nine have spans of 16 ft. 8 ins. The columns and pilasters carry ten transverse girders and three longitudinal girders, each girder being continuous over all intermediate supports. The girders in turn carry a continuous floor slab without stiffening ribs or beams. This girder and slab construction is shown in detail by Fig. 1. Referring to the drawings, it will be seen that the girder rods are carried over the column supports, and that the slab rods are carried over the girders from one bay to another. This last detail is more clearly shown by the view, Fig. 2, which also shows the wire mesh enveloping the girders and the tin plates for spacing the floor rods and holding them in position. The netting used is McMullin's diamond mesh, 4 × 2 ins., with the 4 in. dimensions running transversely of the girder. The other details are shown by the drawings.

Fig. 1 also shows the column construction. The columns are round and are reinforced by peripheral vertical rods connected together by hoops riveted at the joints and fastened to the vertical rods by U-bolts. The vertical rods and hoops are wrapped with wire mesh of the same character as is used for the girders, and this mesh is tied firmly to the rod and hoop frame. As constructed the column reinforcement is handled and set into the forms as a unit. The view, Fig. 3, shows several of these column units ready to be placed. It will be noted that four of the column rods are bent outward at the top of the column so as to penetrate the girder concrete and tie the column and girder together.

Referring now to the reasons adduced in favor of this form of reinforcement, we have first the

Equivalent Heights in Feet for Artesian Heads of 1 to 99 lbs.

(Assumed weight of water, 62.5 lbs. per cu. ft.)

| Pounds (tens). | Pounds (units). | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| | Feet. | Feet. | Feet. | Feet. | Feet. | Feet. | Feet. | Feet. | Feet. | Feet. |
| | | 2.3 | 4.6 | 6.9 | 9.2 | 11.5 | 13.8 | 16.2 | 18.4 | 20.7 |
| 1 | 23.0 | 25.3 | 27.6 | 30.0 | 32.3 | 34.6 | 36.9 | 39.2 | 41.5 | 43.8 |
| 2 | 46.1 | 48.4 | 50.7 | 53.0 | 55.3 | 57.6 | 59.9 | 62.2 | 64.5 | 66.8 |
| 3 | 69.1 | 71.4 | 73.7 | 76.0 | 78.3 | 80.6 | 82.9 | 85.2 | 87.6 | 89.9 |
| 4 | 92.2 | 94.5 | 96.8 | 99.1 | 101.4 | 103.7 | 106.0 | 108.3 | 110.6 | 112.9 |
| 5 | 115.2 | 117.5 | 119.8 | 122.1 | 124.4 | 126.7 | 129.0 | 131.3 | 133.6 | 135.9 |
| 6 | 138.2 | 140.5 | 142.8 | 145.2 | 147.5 | 149.8 | 152.1 | 154.4 | 156.7 | 159.0 |
| 7 | 161.3 | 163.6 | 165.9 | 168.2 | 170.5 | 172.8 | 175.1 | 177.4 | 179.7 | 182.0 |
| 8 | 184.3 | 186.6 | 188.9 | 191.2 | 193.5 | 195.8 | 198.1 | 200.4 | 202.8 | 205.1 |
| 9 | 207.4 | 209.7 | 212.0 | 214.3 | 216.6 | 218.9 | 221.2 | 223.5 | 225.8 | 228.1 |

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†U. S. Geological Survey, Washington, D. C.

‡See the author's article on "Artesian Flows from Unconfined Strata," Eng. News, March 30, 1905.

use of the enveloping wire mesh. Mr. Turner states that the use of the netting is an "attempt to duplicate the conditions of dissemination of reinforcement under which Considere has shown that the elongation of reinforced concrete in tension is from 12 to 15 times what it is without reinforcement." The idea of the unit reinforcing frame for the columns is, of course, to facilitate the placing of the column reinforcement, thus reducing the cost, and to insure the accurate location of the reinforcement in its concrete envelope. In reference to the plain floor slabs, Mr. Turner says:

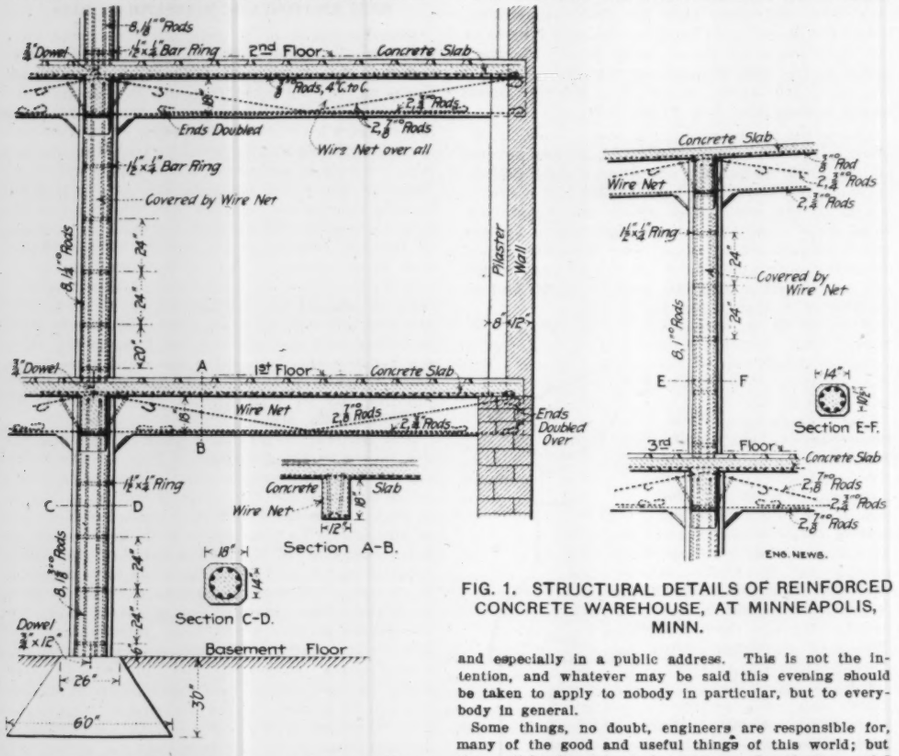


FIG. 1. STRUCTURAL DETAILS OF REINFORCED CONCRETE WAREHOUSE, AT MINNEAPOLIS, MINN.

> In constructing work in this line it is well to bear in mind that centering is a considerable item and that each additional beam is an extra expense. While we may not discard beams for heavy work, for light loads, such as 200 to 400 lbs. per sq. ft., we may use safely a simple slab from column to column, for spacings of 16 to 18 ft., running main lines of reinforcement from column to column directly and reinforcing transversely with lighter fabric between these lines.

So much for the reinforcement. For the concrete a 1-2-2 Portland cement broken stone concrete was used and was mixed so wet that it would pour readily. The stone was screened from dust and varied from pea size to particles passing a ¼-in. screen. This will be recognized as an unusually rich concrete for this class of work, and the engineer defends its use in the following words:

> We use more cement than do most others, but by flooding the concrete into place we can place the mixture at a lower cost per cubic yard than can be done with a cheaper mixture which has to be tamped into place. Moreover by the use of plenty of water we ensure a dense concrete and one which gives a good surface and perfect adhesion to the metal. Again the excess of water causes the surface to harden very slowly, thus insuring a more perfect bond between old and new work.

In closing, brief mention should be made of the system of forms designed by the engineer for the column and beam work. These forms are shown in detail by the drawings of Fig. 4, and the chief claim made for them is their light weight and the ease with which they can be erected and taken down. The view, Fig. 3, shows the appearance of the forms when erected. In case the span requires intermediate support of the girder forms, this is furnished by setting studs with caps at the necessary intervals.

The building was constructed by John Wunder, of Minneapolis, Minn., as contractor, and C. A. P. Turner as engineer. The system of construction has been patented by Mr. Turner.

## THE ENGINEER'S FAULT: A DISCUSSION OF SPECIFICATIONS, CONTRACTS AND LAW SUITS.*

By John Cassan Wait,† M. C. E., LL. B., M. Am. Soc. C. E.

"The Engineer's Fault" is perhaps to the engineering profession a significant title and one which might be enlarged upon to the unhappiness of engineers if the purpose of the author were to take up and to point out the faults of individual engineers, or if the faults of any particular engineer were brought directly to his attention, and especially in a public address. This is not the intention, and whatever may be said this evening should be taken to apply to nobody in particular, but to everybody in general.

Some things, no doubt, engineers are responsible for, many of the good and useful things of this world; but they will hardly claim to be paragons of perfection, and I believe will confess that they have faults. In this address I desire to point out not only faults for which the engineer is responsible, but faults with which he is charged, whether responsible or not, and particularly those faults which arise from the engineer's practice in conjunction with the departments of the municipality, more particularly with the law department.

The engineer is the mainstay and the back-bone of the department. He ought to be. Each new administration brings new and unfamiliar, if not ignorant, heads to departments. In some departments he is not only the engineer in name and reality, but he is the administrative, the legal and sometimes, I am led to believe, the political adviser of the head of his department.

The wonder is that engineers have not the same persuasion as to their real merit and value in dollars and cents, and that their salaries are not commensurate with their services and the confidence reposed in them. The engineer's fault is that he is willing to accept confidence and responsibility in part payment of his services, in lieu of gold. At the end of the year he is likely to complain that it does not pay his house rent and provision bills.

On this subject much might be said, but my question is, whose fault is it? Is it any one's fault in particular? And I fancy I can hear the rank and file of the society say that it certainly cannot be charged to us. I quite agree with you that the fault is higher up, when members of our profession who are the heads of important commissions and receive $10,000 to $12,000 per year for only a part of their time, and who, with their associates, assistants and subordinates, have their own expenses paid out of the public treasury, and whose recommendations are law, recommend that the rank and file of their bureaus of competent engineers shall receive salaries of from $1,200 to $1,800 per annum. The fault is apparent.

The engineer has not to contend with title and guaranty companies, indemnity companies, corporation companies, collection agencies, patent and trade-mark agencies, like the "Scientific American" and the legal aid societies, which rob the legal profession of large branches of its legitimate practice. So far the practice of engineering is comparatively unimpaired by professional corporations, but I can see in the existence of the testing companies and in the monopolistic manufacturing companies that destructive influence will be wrought to the engineer's professional work. Few of you engaged in municipal engineering perhaps realize the effect of these, but their influence is far-reaching and very damaging to professional success, or its existence even, not only to civil engineers, but to the several branches of industrial engineering. This may be charged chiefly to the tendencies of American business methods. The avowed purpose is to eliminate the middleman and the small operator and to deal directly with the purchaser or consumer, and to provide or sell finished structures or plants erected in place, thus dispensing with professional engineers, lawyers and ministers even. This applies especially to the great bridge companies, the great steel companies, the great electrical manufacturing companies, and generally to combinations for the manufacture of pumping and refrigerating plants, railroad motive power, rolling stock and others too numerous to mention.

Having a monopoly of the raw materials and of the

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FIG. 2. VIEW SHOWING FORMS AND REINFORCEMENT FOR FLOOR SLABS IN MINNEAPOLIS WAREHOUSE.

FIG. 3. VIEW SHOWING COLUMN AND GIRDER FORMS FOR MINNEAPOLIS WAREHOUSE.

finished product, these great corporations have it within their power to become worse than the slave-holders of 1860, as employers. Being a law unto themselves, they are invulnerable to the attacks of lawyers, exercising the whip hand over contractors and consumers who dare to litigate disputed claims. Being invulnerable to attack, they have little fear of litigation and no cause for remorse. There is, therefore, less need for the prayers of the saintly.

The result of all this is that our engineers are becoming specialists of the factories and shops and operators, the employees of erectors and foundation specialists, or they remain draftsmen and waged employees of the great manufacturing concerns.

INSUFFICIENCY OF PRELIMINARY INVESTIGATIONS.—A failure to make a proper preliminary investigation of the site of the work is most prolific of law suits and litigation, and occasions much controversy between engineers and contractors, especially when the preliminary investigation made by the engineer is subsequently disowned by him. I refer to the engineer's investigations to determine the character of the sub-strata and its bearing capacity for structures, which includes soundings, borings, test-pits and other operations adopted by the engineer to ascertain the character of excavations or of sub-stratum and the expense of excavating the same, or its capacity to sustain loads or their impenetrability to water or other liquids. Engineers spend months in making investigations of this character and then they disclaim any responsibility for the results thereof and deny that they know anything whatever about the conditions prevailing at the site, but they do expect or require a contractor in a few days, or at most a couple of weeks, to conduct experiments and make such investigations as will enable him to stake his entire fortune upon them. Is not this the engineer's fault?

Who is best able to assume the risks or to insure the stability of work erected upon such a site? The municipality which has conducted most extended investigation, or the contractor who has made none? Examples are indeed numerous. They have occurred on our New Croton Dam, dry-docks, in the improvements at Annapolis, on the Erie Canal, and in nearly all government work.

I had occasion a short time ago to read a contract and specifications as counsel and to pass upon it. The specifications recited that the city engineer had investigated the sub-strata and knew it to be substantially as represented; that if it were not so the city would make good the contractor's loss and any damages sustained. This is extraordinary. This is the first case that has ever come under my observation.

It is truly the most economical practice. It brings the bids to a standard of comparison. It gives to the city or government the benefit and advantage of all the money it has expended in preliminary investigation. It promotes engineering practice and saves contractors from disaster and ruin.

No one thing contributes more to the disaffection between contractors and engineers and to righteous indignation of the former than the disavowal of results of the engineer's investigations.

Is it the engineer's fault? The clause is no doubt the creation of the Law Department, but, on the other hand, it is counselled by the engineer and no doubt is a safeguard to his professional reputation, and an assurance which most engineers are very willing to adopt to save themselves from criticism and discharge in case of reckless or indifferent work or insufficient care in making the investigation.

I have sometimes wondered if such safeguard stipulation were kept in use that an engineer might misrepresent the condition of things, giving to favorite contractors the true condition of affairs, thus enabling him to more successfully compete and to secure the award and contract. How easily this could be done every one in this society knows.

The abolition of this clause, this disclaimer of an engineer's professional work, is one thing that I had hoped to correct before leaving the corporation counsel's office.

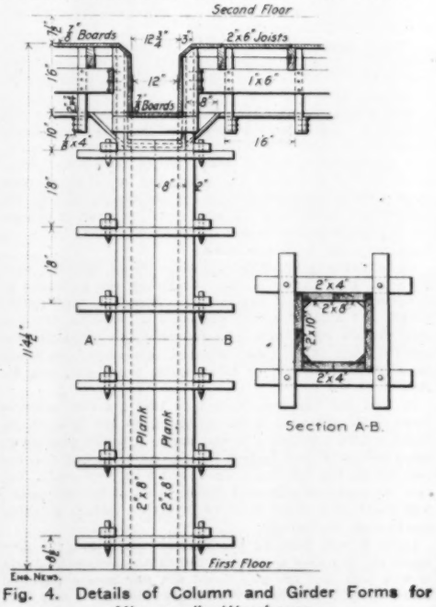



Fig. 4. Details of Column and Girder Forms for Minneapolis Warehouse.

I am fully convinced that it is wrongful and against the interests of all parties concerned, except perhaps the politician and his favorite contractor. It will be very difficult to do this, because anything that affords personal protection to an engineer and safeguards dire results from his errors and neglect will be difficult to eliminate, however unjust to the contractor or expensive to the municipality. Moreover, the law department feels a substantial judgment against the city, when it is not cognizant of the enormous saving to the city resulting from intelligent bids for public works. With the engineer and the law department in favor of the clause, there is little hope for the public treasury or the contractor.

INSUFFICIENCY OF PLANS AND SPECIFICATIONS.—Under the topic of "specifications and plans" there is one subject which I feel it proper to discuss and which may properly come under the subject of the "engineer's fault" as against the "contractor's fault." I now refer to insufficient plans and specifications as against defective workmanship. The engineer, in his desire to keep up with the rapid industrial progress now developing and to adopt every new and improved device of construction and every improved class of material, sometimes permits his zeal to exceed his discretion. This occurs when the engineer adopts materials or processes of construction without a thorough investigation and test of their qualities and their durability.

I do not think that the engineering profession is as culpable in this particular as are architects as a class, but misfortunes do occur in consequence of the failure of the engineer to take proper and reasonable precautions. This results in experimentation on the part of the engineer, and usually at the expense of the contractor. The engineer, not having the power to use or appropriate the funds of the municipality for purposes of experimentation, and not being, therefore, authorized to certify work that has been done and afterwards condemned, the contractor is left to foot the bill without remuneration, from the municipality.

A like situation arises where the plans or designs of the engineer are insufficient and where unwarranted weaknesss develop in the structure, or even where the ultimate completion of the public improvement is prevented.

If the site of the proposed improvement has not been sufficiently examined and developed to reveal the conditions existing and the character of the sub-strata, as for foundations, and the structure fails, then the question arises whether the failure of the structure is due to defective plans or to insufficient investigation in the preliminary work. Plans designed for conditions that do not prevail are insufficient for the location where the structure is ordered built, though they might be entirely sufficient at some other site, and an engineer may reasonably be charged with defective designs for a structure to be built upon an insecure site, as well as for the failure to make proper and sufficient investigation to determine the character of the sub-strata upon which the structure is to rest.

If a structure fail from inherent defects in design, and the builder is by his contract required to follow the engineer's plans and specifications, it would be manifestly unjust to hold the builder responsible for the failure, unless, indeed, the engineer seeks to make the builder an insurer of his professional skill and designs, thus confessing the superiority of the layman over the professional engineer or architect.

This is the effect of some specifications by architects, and in some instances of engineers. It may be excused in cases where the builder is a specialist in his line, as the American Bridge Company in steel structures, the National Pump Co. in hydraulic machinery, or the Westinghouse and General Electric companies in electrical plants; but in such cases, were it not better for engineers to designate the site or place for the works, the capacity, efficiency or duty of the plant or structure as the work it shall perform or the loads it shall carry, and leave the specifications and plans to the bidder, being careful to describe explicitly the tests of efficiency to be required? Such a practice would relieve the engineer from the charge of adopting certain manufacturers' plans and specifications and features, and of making an effort to stifle competition by limiting the bids to one or a few bidders. The courts are keenly alive to this situation and they are likely to hold that a construction company is not an insurance company and that however many so-called guarantees—more properly called warranties—the engineer injects into his specification, such as to warrant the cellar, sewer or reservoir to be water-tight, or the structure to carry certain loads, or that the structure shall be stable and resist the action of the winds, waves, tides and floods—they do not constitute a warranty where the contract specifies the dimensions, design and members of the structure and the character of materials, the process of mixing and placing. A warranty by a builder as to results implies that he shall have some say as to the design and methods of erection.

The results desired may be secured by specifying conditions and tests that must be met, thus encouraging manufacturers to meet the conditions by improving their goods, machines and plants and creating healthy progress in the industrial arts. By all means, the engineer should avoid the imputation of being owned by any particular interests, local or outside. The politician's policy of local patronage is a dangerous one when the charter and ordinances forbid it. This situation presents another one for a diplomat-engineer.

If the local manufacturer or builder, having the advantages of proximity to the work, knowledge of conditions, acquaintance with the labor and material market, and a thousand other things, cannot compete with the outsider, then something is the matter with the local

bidder. He needs no inside information nor favoritism; it is more likely that some one other than the contractor is being benefited.

TIME LIMIT.—This is another thing prolific of complaint, controversy and litigation, especially when a substantial sum is named as a penalty or liquidated damages for delay.

Probably no one thing is made the subject of greater abuse in governmental work, and especially right here in New York. It has become so flagrant that the courts almost uniformly refuse to enforce stringent contract clauses for liquidated damages, and the time limit of a contract with the city has become virtually "a dead letter." Whether from intrigue and connivance with favorite contractors, proteges or politicians, from lack of practical experience and knowledge of engineers and architects, or from sheer negligence, I do not need to inquire, but I do declare that something should be done to rectify this evil. Without doubt many things contribute to the determination of this period of time. The engineer does not always have the final determination of it. His recommendations are sometimes ignored and the time arbitrarily fixed by somebody else. The effect, however, is apparent. Outside bidders, not assured that the time limit will not be enforced, or that they may continue their work into a favorable season or over two seasons, cannot compete with contractors who have that assurance or who feel that they will get indulgences. If the time be short, the assured gets the contract, and the more conservative and careful bidder, the business man, loses to the gambler or politician, the assured.

This, however, is but one phase of the time limit, when not enforced. It is the city and the public that get the burden and the disagreeable end of the bargain. Was there ever such intolerable delay experienced as has characterized the Elm St. improvement, where the property owners, from one end to the other, have been nearly bankrupted by the tying up of their property for more than eight years?

As aggravating instances occurred in our Rapid Transit construction, which contributed so much to the Elm St. condition. The Subway contract provided that openings of streets should continue only for thirty days, except by consent of the abutting owners. Yet those Subway excavations were opened and maintained open for periods ranging from six months to twenty months, and the streets encumbered for even longer periods, to the destruction of business and property interests, to say nothing of inconvenience. That this was necessary may be gravely doubted. It was avoided in some places where influence would not tolerate it. It is not found necessary in lower Broadway, as now being constructed.

These are two of many examples. We have the Hall of Records, the Blackwell's Island Bridge, the new East River bridge and its approaches, including Delancey St., the three great reservoirs, that are each years past the times set for their completion, some of them at a cost greatly exceeding the original contract price. Had other bidders known they could have taken their own time for the works, how much cheaper would they have been undertaken?

Nobody knows better than the author that part of the delay to some of these works has been due to conditions not within the control of the engineer or the contractor, but a great deal of it is wholly inexcusable and the result of the grossest indulgence.

Nor is this all. If, as is frequently the case, the public work has been awarded to several contractors and the completion of some parts of the work depends upon that of others, then some contractors suffer very great loss, to the favoring of others. The new East River bridge affords a mischievous example of this, where the work of the contractors for the anchorage was suspended for five ane one-half years, during which time the time limits of other contractors were several times extended on no apparent excuse, but as indulgences. During this time the plant and temporary works of the anchorage contractor had deteriorated and had to be renewed, the price of materials and labor had greatly increased, and several of the engineers and contractors, their superintendents and foremen, were dead, and the prospective profits were multiplied into losses. Were the engineers who recommended the extensions at fault? Will the city make good such losses? Not if it can avoid it.

This is an instance of the evil results of dividing the responsibility of erecting and completing a public building or structure among several contractors. It is a practice usually attended with delay, shifted responsibility and subsequent controversy.

PLANS FOR A COMPLETE WORK.—Another feature to be observed, essential to the success of a public improvement, is to have the specifications and plans describe and show a complete structure. A failure to do this occasions delay and brings on all the trouble and conflict arising from having several contractors on the job. Nor is this all; it leads to the unhappy conditions that exist on so many of the great public works at present. Thus, great bridges are planned; they are erected after years of delay, and then no thoroughfares or means of transportation are provided by which to convey the traffic. Great piers and abutments are erected, to stand for years awaiting the superstructure. Park property is acquired; buildings and structures are torn down and the land allowed to lie unimproved for years thereafter. Great reservoirs are planned and started under contract without provision for auxiliary structures, which are built long after, when they might have been started contemporaneously with the principal structures. These conditions are not usually the fault of the engineer, but the fault of the power that authorized the work and made appropriation therefor; or, rather, that fails to authorize and appropriate. However, the engineer should exercise his persuasion to have the contract for a complete work.

LIQUIDATED DAMAGES.—There is a popular notion that liquidated damages cannot be assessed for delay; and that is pretty nearly correct with a municipal corporation. The right to retain a sum as liquidated damages does not, however, as is supposed, depend in any way upon the bonus offered or upon the fact that any bonus was offered. The difficulty in recovering liquidated damages arises from the trouble of showing that the city has suffered actual damages or anything more than inconvenience. The policy of the law forbids the recovery of any damages but the actual damages.

LABOR CLAUSES.—Many clauses are required to be inserted by the ordinances, the charter and legislature. Of these there were several labor law clauses—one as to hours of labor, another as to the payment of the prevailing rate, one as to the employment of citizens only, one as to using stone cut within the limits of the State. All are now declared illegal and unconstitutional, after eight years of folly on the part of city officials, intolerant insolence on the part of labor leaders, the usual losses and damages to contractors, and the wicked waste of public funds. There was never any doubt but that the law was unconstitutional. Every layman contractor felt it.

ASSIGNMENTS.—Another clause required to be inserted in our contracts is that prescribed by Section 444, Laws 1897. This act forbids the assignment of any contract or of any money earned or unearned under public contract, without the consent of public officers, etc. It is as unreasonable as the labor law. It was first held to forbid the assignment by a contractor of moneys earned. The idea of denying one's right to dispose of what is his own, or of his power to pay his just debts with his just claim! It took a creditor's action to test the law and to dispose of it. The courts, in their charity to the legislature, held that the law was only intended to prevent the subletting of work to irresponsible or incompetent contractors, and to make the public official the judge of their responsibility and competence to undertake and do the work.

ABANDONMENT CLAUSE.—There are two clauses in our municipal contracts that are iniquitous and of doubtful legality. One in the abandonment or dismissal clause, which provides that if the city take over and complete the work and there be any surplus of the contract price over the actual cost to the city, that such surplus shall be forfeited to the city, which shall be entitled to retain it, etc. I have no doubt but that our courts would refuse to enforce such a clause. It is inequitable and unjust and would never be favored by our courts. During the Low administration it was by my own persuasion directed to be stricken from the city contract, but I notice it is still retained in some cases. On what ground I do not know.

SUSPENSION.—Another clause that is inequitable and unjust is that reserving power to the city to suspend work for an indefinite period. If the city suspend work, can it reasonably ask a contractor to return and complete a structure when the labor and material markets have greatly advanced during the suspension and to the contractor's great loss? I think not. The period of suspension permissible should be fixed at thirty or sixty days, or some limitation made.

PATENTED ARTICLES.—Another clause inserted pursuant to the charter is that forbidding the purchase of patented articles or pavements. This has been interpreted and applied by the corporation counsel's office to suit various conditions. To reconcile the opinions sent out from the office under different administrations would be a difficult matter, or to reconcile them with the decisions of the courts.

In 1902 the Supreme Court held that armored concrete made with expanded metal weighing 85 lbs. per sq. ft. could not be specified. It was shown that the patents on expanded metal had expired by limitation, as had also the patents on the machines upon which it was made, but that the requisite expanded metal, being of heavier metal, was made on a large machine involving certain patented mechanical movements.

Later it was held by the highest court that the city could not purchase a patented bitulithic pavement. Again it was held that the city could not purchase a patented water-meter. Yet, in view of these deisions, it was held by the law department of the city that the section of the charter was not violated by the purchase of a particular manufacture of library stack built under no less than five patents, notice of infringement of which was sent to every competing bidder. There you are, and if you cannot discover the dividing line in the preparation of your specifications, then, of course, it is the engineer's fault.(?)

Laws are enacted, without doubt, for good and proper purposes, at least ostensible, but it does seem frequently that they are two edged and sometimes sharpened at both ends, and fall far short of their apparent [illegible] would seem to be true of some of the co[illegible] mentioned. While keeping out objection[illegible] olistic persons and things, they secure[illegible] which do get in, lawfully or otherwise[illegible] by favor or exemption relief from them.

INDEMNITY CLAUSE.—The indemnity [illegible] densome one to a contractor, notwithstan[illegible] relief afforded by the casualty insurance [illegible] usually provides that the Comptroller may [illegible] sum as in his opinion shall protect the c[illegible] Whether it be a property holder or a person [illegible] clause is used as a club to exact money f[illegible] tractor. By filing a claim with the Comptro[illegible] ter whether meritorious or otherwise, the [illegible] grieved can tie up the contractor's money in a[illegible] to ten times the damage suffered, and without [illegible] any responsibility whatever, and on the sli[illegible] text.

PATENT RIGHTS INFRINGED.—Another pro[illegible] our contracts is that which makes the contrac[illegible] sible for all infringement of patents, etc. This might be made very burdensome if enforced in some cas[illegible] How can it be justified in view of Section 1554 of the charter, forbidding the purchase of articles or pavements, the subject of patent right or proprietary ownership? Is the contractor responsible for the infringement of process or materials specified by the contract, if his contract is illegal, being forbidden by said section?

EMPLOYMENT CONTRACTS.—This contract clause indemnifying the city was embodied in the city's contract of employment of engineers and architect. As is well known, the architects always insert in their contracts a clause declaring that the plans and specifications are the property of the architect. That being so, they must be the creation of the architect and he should be willing to protect the city from suits for their infringing either the copyright or incorporeal right of others. Surely no other reason could prompt the requirement that all drawings should be returned to the architect, except to preserve the right to the incorporeal design embodied and described. Likewise of the engineer.

The anxiety which that one clause aroused and the wire-pulling which was made to have it and other clauses expunged were interesting and amusing. Committees and delegations from the American Institute of Architects visited the Corporation Counsel to secure its withdrawal and I believe they succeeded. Not one was willing to guaranty the originality of his designs, not to protect the city from suits for infringements, contained in his own plans. It's different, you know, when these things are applied to the party himself, who may be the author of them. I recall in particular one engineer who raised special objection to this clause. He had been called in as a specialist to design a municipal plant. On being asked if he had himself designed the plant, he declared in the affirmative. The plant had hardly been started when suits for patent infringements were threatened by several patentees and it became apparent that this engineer had employed patent specifications and drawings in the creation of his design and reasonably should have anticipated infringement suits; hence his anxiety to relieve himself from the onerous clause. However, the contract approved by the engineer and the law department securely bound the contractor to indemnify the city, and you may believe it put him on the anxious seat. Was this the engineer's fault?

I may add that this idea of architects that they have inherent rights in the designs incorporated in their drawings, after a structure has been erected, should be corrected. A recent decision by our Appellate Division Court has disposed of the question. Building from them has been held a publication of the plans, destroying common law rights in the creation.

It may be gravely doubted if that is what prompts many architects to require a contractor to surrender his plans, specifications, contract and all written orders even. It savors very much of the fox and a very probable desire to cover one's tracks and deeds; and to deprive the contractor of his documentary evidence of what has actually been done and taken place. A case recently came to my attention where the architect demanded back all his letters and correspondence as a condition of granting his final certificate. These are faults of the architect. I have never had occasion to attribute them to engineers.

CHANGES AND ALTERATIONS.—The subject of changes and alterations should be mentioned briefly and this seems to be a proper place to take it up. The conditions and necessities of work frequently require changes to be made. When changes are made and they increase the cost of the work to the contractor, he should be compensated for such increased cost, and liberally, too. Engineers are generally agreed in that, but frequently they do not allow to the additional cost of alterations and they excuse themselves upon the ground that they have granted and given to the contractor many favors, omissions and deductions, which are more than equal to the additional charges imposed upon him. This is not only a mischievous position to take, but it is unwarranted and dangerous. Usually the law will hold that where omissions, favors and deductions have been granted, they can not be offset against increased or additional work required; unless, of course, they are the subject

xpress agreement by the contractor. All deduc- d omissions should be as much the subject of a agreement or order as should the additions and ade.

TEN ORDERS.—Municipal contracts usually pro- st no extra or additional work or materials shall for unless authorized in writing and the price greed upon before the work is undertaken. this clause is employed the engineer should not additional or extra work without giving and such an order and it should be his purpose to that such orders be made and filed. Nothing annoying or detrimental to the reputation of the than his postponing his determination as to in his opinion certain work or materials are ex- To refuse or neglect to determine this question and such accounts for extra work as a threatening over the heads of contractors is, to say the least, a fault, and unfortunately it is a too frequent prac- with engineers and architects. It is not necessary work be completed or that successive monthly estimates be made before the question is determined whether or not the contractor is to receive extra compensation for work that he is doing or has done. Such a course deprives the contractor of the benefit of this clause, as well as the owner, and in most cases it turns out that the engineer has been playing with the contractor without any intention of allowing extra remuneration for such work, which leads to bad feeling and bad repute. It is usually the engineer's fault.

ENGINEER AN ARBITRATOR.—This presents the contract clause giving to the engineer or architect the determination of all questions in relation to said work and the construction thereof and of every question which may arise relative to the execution of this contract on the part of the contractor, and that his estimate and decision shall be final and conclusive and a condition precedent to the right of the contractor to receive any money under this contract, and in some instances making the contractor's recovery subject to the obtaining of the engineer's certificate, and limiting the amount to be paid to the amount certified.

It is generally held that this clause confines the engineer's or architect's determination to questions arising in the work. It does not authorize him to determine the construction of contract clauses, nor the question as to whether there has been a breach of contract, nor the amount of damages resulting therefrom, nor the amount necessary to indemnify the city for losses suffered. It does not give to the engineer the determination of what is extra work or the amount of extra work, unless it be expressly so stipulated.

These clauses are not generally in good favor with the courts. They are regarded as conditions precedent and as clauses stringent and unreasonable. The courts are frequently aroused to jealousy by the feeling that such clauses are used to oust the court of its jurisdiction, and are then frequently declared to be void and of no binding effect. Such cases are where they are drawn too stringent or drastic and thus arouse the feelings of the court that an injustice has been done to the contractor. In most cases such a clause is held to apply only to the manner, method, means and materials by which the structure is accomplished, and which are within the special knowledge and experience of the engineer or architect, and this would seem to be the most reasonable interpretation. Such a construction is borne out by the clauses which immediately follow and which give to the engineer the power to inspect labor and materials or to reject and accept them and to require that defective work or materials be removed and not used again upon the works.

Engineers in performing the duties imposed by these clauses should not forget that they are in effect arbitrators between the city and the contractor. I appreciate that it is difficult to conceive a man an arbitrator and in the employ of one party to a contract, and that he is expected to be perfectly fair and unbiased with the contractor; but it is only upon the ground that he can be and will be fair and equitable that this clause of our contracts can be sustained. If it be shown that an engineer is biased, prejudiced and not judicial in his determinations, then the contract clause should fail and the engineer's determination should be annulled just as much as any award made under any common law arbitration. If the engineer be regarded as the agent of the city, then the contract clause makes the city or its agent a judge of its own case, which is contrary to the elementary principles of our jurisprudence. A contract may not be drawn leaving to one party the determination of questions affecting the rights of the other party, and such contracts are universally held to be invalid.

LITIGATION.—The public improvement having been projected, authorized, contracted for and completed, the estimates made and the accounts having been rendered and certified, there still follows the sequel. By this I mean subsequent litigation. In this the engineer who has had charge and who has been frequently a part of the structure itself, is or should be the most important witness. It is upon him the city must depend for protection of its rights and its treasury, and it is here that a very important element of the true value and importance of an engineer is shown. His duties are not limited to the preliminary surveys, preparation of specifications, plans and the contract, and the supervision of the erection of a structure, but he must also be prepared to protect the rights of his employer in what may come after. This, I think, is perhaps the weakest point of engineers, and it comes largely from their failure to appreciate what is required of them in the trial of an action in court or before a referee. The fault lies largely from the want of detailed memoranda of facts, circumstances, measurements and dates. One of the greatest faults of engineers is their failure to date each and every memorandum, estimate or fact recorded. Notwithstanding the training which engineers get in school and in the field, and the frequent and repeated instructions by their employers to date every entry, memorandum or statement made, it is my observation, founded upon a long experience, that engineers, superintendents and foremen do not date their notes.

TESTIMONY.—In order to prove anything before a court or a referee, it is essential that the witness should know as to what he testifies, from his actual knowledge, acquired through one or any of his five senses. He can not testify from books kept by time-keepers or bookkeepers, but should and must be himself conversant with the actual conditions, facts and circumstances prevailing and about which he seeks to testify. It is necessary, therefore, that he should be present when measurements are made, and actually take part if possible; that he himself should note such measurements and should himself note the presence of laborers and mechanics, the number and the actual time employed in doing certain kinds of work, which may subsequently be the subject of litigation. It is not always sufficient that he has seen the work done; that he knows the reasonable value thereof per unit measure; and that he has since measured it. He should know himself the actual time spent or the actual amount of work or the actual cost. In short, he should know absolutely within himself whatever he expects to be a witness to. It is a mistake for engineers, foremen and superintendents to leave things to the time-keeper and to the bookkeeper. Personal memoranda from personal observations and measurements are worth very much more to a case than any number of account books.

TRIAL.—The prosecution of a law suit involves first a clear and lucid declaration of the facts in the case. Conclusions, statements of law and arguments should be omitted from the complaint, as they have their place in subsequent proceedings. Lawyers depend largely upon engineers to assist them in the collection and presentation of these facts, and therein lies two-thirds if not four-fifths of the battle. If this be true, and I do not think that it can reasonably be denied, it must be conceded that frequently there is more truth than libel in the frequent arraignment of lawyers that the loss of the case was the engineer's fault, meaning thereby the witness's fault.

The chief reasons why engineers do not make successful witnesses are, in my opinion, the lack of thorough understanding between the attorney and engineer; the want of information on the part of the engineer as to the shape in which the facts must be presented to the court, and a lack of self-possession, and the prompt comprehension of the English language by the engineer.

EXPERTS.—It is not to be wondered that there should exist a strong antipathy between the engineer and the lawyer, and it finds an expression on the part of both sides in contemptuous expressions, and especially after an advocate has been defeated by the testimony of an expert engineer more carefully schooled and trained in the art of answering questions by his opponent than his own witnesses. It is my opinion that it is the engineer's fault that experts have the awful reputation which the legal profession give to them for the reason that they permit themselves to be biased and be made advocates by the lawyers themselves.

CONCLUSION.—The industrial progress of the world is built upon a graveyard of errors. Engineers need not blush at a rehearsal of their faults, or when accused of having faults. It is to be hoped that they will venture, that they may attempt new ways and means, even at the expense of an occasional failure. Such men are progressive, they work under pressure. What matter if they occasionally let a man out and up through the East River heavenward, or if they drop the City Hall into a sewer trench; it at least shows that something is doing; and worse things have been done than to build bridges where not needed, or to build them where needed, but without the means of utilizing them; and it is better to have built some things and to have them fall, than to have never improved our methods and materials of construction. Faults belong to those who undertake, to those who do and we may well shoulder the faults, the errors and mistakes with the great results being accomplished.

## RECONSTRUCTION OF THE HORSE RUN VIADUCT: CINCINNATI SOUTHERN RAILWAY.

In the construction of the Cincinnati Southern Ry. (described in our issue of Feb. 20, 1902), several steel trestles were built, which were amply strong for the engine loads and traffic of that time (some 30 years ago), but which now have to be replaced by more substantial structures adapted to the greatly increased engine loads and train loads of modern railway practice. A good example of this class of work is the Horse Run Viaduct (Bridge No. 8) at Ludlow, Ky., about three miles from Cincinnati, O., the reconstruction of which has recently been completed. Fig. 1 is an elevation showing the old and new structure, and Fig. 2 is a view which shows the comparative character of construction. Perhaps no example more forcibly illustrates the great changes that are taking place in railway structures in the lapse of time than this viaduct. The rolling load for which the old structure was proportioned consisted of two engines weighing with loaded tender 66 tons each, followed by a freight train load of 1,800 lbs. per lin. ft. The new viaduct was proportioned for a load of two engines weighing 178 tons each, followed by a freight train load of 5,000 lbs. per lin. ft. for each track. The total weight of iron in the old single-track structure was 319 tons. The new double-track structure is 60 ft. longer than the old one, and the weight of the steel in it is 2,250 tons. On the basis of the same length, the new structure weighs 6.8 times as much as the old structure.

The old structure was built by the Keystone Bridge Co., and was completed in 1876. The contract for the new structure was taken by Mr. C. L. Strobel, contracting engineer, of Chicago. He also prepared the designs under the general direction of Mr. G. B. Nicholson, Chief Engineer, and Mr. H. E. Warrington, Assistant Engineer of the railway company. It is a curious coincidence that Mr. Strobel was also connected with the building of the old viaduct, as Bridge Engineer of the Cincinnati Southern Ry. The shop plans for the new structure were prepared in Mr. Strobel's office; the shop work was furnished by the Mount Vernon Bridge Co., and the steel by the Carnegie Steel Co. The erection was conducted by his own organization.

The old single-track viaduct had 30-ft. spans, with Keystone octagon columns and girders formed of trussed I-beams, on the Fink system. The bents were connected by longitudinal bracing so as to form towers of two and three spans each. The viaduct is on a grade of 1.14% (rising to the south), and engines with heavy freight trains starting from the Ludlow yard pull very hard in crossing the viaduct. The new structure has plate-girder spans of 60 ft. and the columns are so spaced that the new bents come between the old bents. Alternate pairs of bents are connected by longitudinal bracing to form towers. There is a 75-ft. span at the north end, and an additional 60-ft. span was put in at the south end on account of treacherous material for foundations. New concrete piers were built, and had to be put down to a depth of about 30 ft. on account of the character of the soil. This work, together with the lengthening of the abutment, was done by the railway company, and involved no interference with the old stone masonry.

The total length of the new double-track viaduct is 960 ft. between the parapet walls of the abutments, and the maximum height is 92 ft. from pier to rail level at bent No. 7. The structure is exceptionally well braced and rigid, on account of the grade conditions already noted. On account of the heavier loading, the longer spans and the double track, the columns carry about twelve times the load on the old columns. The columns of the new structure are composed of four angles, with lattice bars and batten plates on the inner and outer faces, and double web plates on the side (transverse) faces. The batter of the posts is 1½ ins. in 12 ins. The top and bottom longitudinal braces of the towers are composed of four angles laced on four sides; the horizontal braces are similar. The longitudinal diagonal braces are of box section, composed of four angles and two side plates, with double lacing on top and bottom. The transverse diagonal braces are composed of four angles riveted back to back in pairs, with double lacing between them. The intermediate horizontal struts of the towers are of box section, composed of two channels set face to face, with double bracing on top and bottom. Between the tops of the columns of each bent is a heavy lattice cross girder, with three panels, as

shown in the elevations of bents in Fig. 3. These girders are 8 ft. 9 ins. deep and have eight flange angles, in pairs, for two web systems, as shown in Fig. 4.

The towers have two special features, both of which are shown in Fig. 5, which also shows the composition of the columns and bracing, and gives some idea of the massive character of the steel construction. The first of these features is the use of pin connections for the longitudinal diagonals, a plan which was adopted mainly to facilitate erection. The second feature is the shoe construction. To the bottom of the leg of the column is bolted a steel casting, having a faced surface which rests on a ⅝-in. gun metal plate, 13 × 13 ins. maximum, on a 2-in. steel plate supported by a set of 16¾-in. plates set on edge and packed close together between side plates. This nest of plates rests on a base formed by seven 15-in. I-beams resting on the top of the concrete pier, with a 1-in. rust joint (of fine cast-iron turnings) between the pier and the beams. One leg of each tower is fixed; the leg transversely opposite can slide transversely; the leg longitudinally opposite can move longitudinally; and the leg diagonally opposite can move both transversely and longitudinally. This construction provides in a simple and positive manner for the movement due to changes in temperature, and also distributes the load over the pier in all directions. It will be seen that some of the packed plates project beyond the I-beam base; this is to provide for the possibility of future adjustment. In case of settlement, jacks can be placed under the projecting ends, and the columns raised to allow of increasing the thickness of the rust joint. The casting on the base of the column projects beyond the sliding plate, so that no dirt can lodge upon this plate. There are two 2-in. anchor rods for each column, set about 5 ft. in the pier and passing between angle brackets on the columns, above which are the nuts.

The spans consist of four lines of plate girders, Fig. 6. The outer ones rest upon the columns, and the inner ones upon the cross girders, as shown in Fig. 4. These plate girders are 90 ins. deep, with single 7-16-in. web plates; the 60-ft. spans have four flange angles 6 × 6 ins., and four ⅝-in. cover plates. The stiffener angles, 5 × 3½ ins., form three 30-in. panels at each end, and 45-in. panels for the remainder of the girder. The sway braces for each pair of girders are set 7 ft. 6 ins. apart with top and bottom lateral bracing in each 7½-ft. panel. Between the inner girders of each pair, cross struts are set at the ends and at 15-ft. intervals at the top, and 7½-ft intervals at the bottom, the latter having diagonal bracing between the girders. This unusually elaborate system of lateral bracing between the girders of the two tracks is due to the fact of the bridge being on a steep upgrade.

The erection of the new structure involved several interesting problems. Its center line coincided with that of the old structure, which had to be kept open for traffic, and the work had therefore to be done around and between the members of the latter, parts of the old bracing being removed as required. The new structure was designed with as few parts as possible, so that the setting of the steel would take but little time (as it was necessary to do all this work between trains), and so that most of the new structure could be put in place before it became necessary to disturb the old structure. The work was further complicated by the fact that the rail elevation of the new structure is 2 ft. above that of the old structure, as shown by Fig. 4. Two steam derrick cars were used, each with a 40-ft. boom capable of hoisting 20 tons. The heaviest pieces to be handled were columns weighing 17 tons and 75-ft. plate girders weighing 20 tons. In setting the columns, the two derricks swung the columns off the car, and while one held the upper end, the other lowered the other end until it stood vertically, when the entire weight was suspended from one derrick while the column was adjusted to place. One of these columns was 64 ft. long and weighed 17 tons. In Fig. 7 the derrick cars are shown in the act of setting a column in place. The field riveting was done by pneumatic riveting hammers, the air being supplied from a compressor and gas engine mounted in a tool car, forming part of the contractor's erecting plant.

The erection was started at the south or high end. All the columns and their bracing and the outer lines of plate girders were set before disturbing the old structure. The two inner lines of plate girders were placed in temporary position next to the outer lines. After this work was done and the north end of the viaduct reached operations were continued in reverse order. They consisted in removing the old track in sections of 60 feet and the corresponding upper parts of the old structure, moving the inner lines of new girders to their final position, and setting the lateral and other bracing. The difference in grade was taken care of by the use of an apron while changing track; this apron was 60 ft. long with a grade of 2.1% from the new track down to the old track. The letters on tower 5-6 in Fig. 1 indicate the order of erection of members of the longitudinal bracing, bent No. 6 being already in place.

While these operations were going on, the new track was maintained in the center line of the structure, making use of the old ties and rails, and supporting the old ties after change of track on the two inner lines of girders. After the new structure was all in place, the new ties and the new rails were put in place for both tracks, and the traffic changed to these. The remainder of the old structure was removed at leisure.

The work of erection was greatly hampered by the necessity of keeping the track clear for [illegible] ins, the actual working time ranging from [illegible] o 6 hours per 8-hour day. This part of the [illegible] d is operated on the train-staff block system, [illegible] h a block station at Ludlow, about a mile [illegible] of the bridge, and another about three miles [illegible] uth. An intermediate block station was establ[illegible] at the south end of the bridge, close to the [illegible] h of the siding for the derrick cars and locom[illegible] e of the work train. When this train occupies the track, the small steel "staff" is on the engine, and the operators at the two main block stations cannot lower their signals or withdraw staffs to permit trains to enter the block. When either one of these operators is notified by the train dispatcher of the approach of a train, he notifies the operator at the intermediate block station at the bridge, who orders the work train to take the siding. The switch cannot be closed and locked without the train staff, and the staff cannot be withdrawn until the switch is properly closed and locked. The staff being withdrawn it is handed to the operator, who inserts it in the intermediate machine, thus enabling either of the regular operators (but not both) to withdraw a staff and lower his semaphore. When this is done, the staff at the bridge cannot be taken out of the machine and consequently the switch cannot be opened to permit the work train to occupy the main track. This system not only protects the work and the regular traffic, but also reduces the delays to traffic and to the work of the erecting gang.

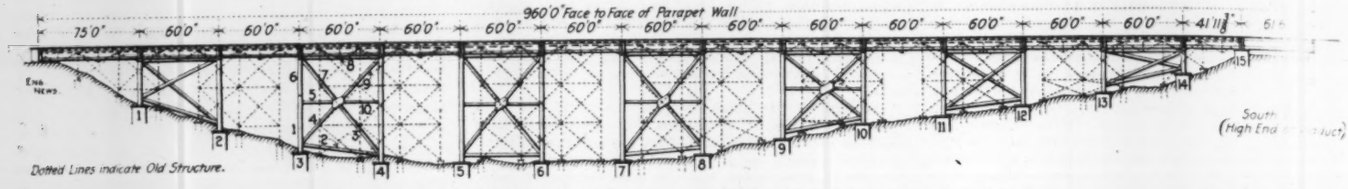



FIG. 1. ELEVATION OF HORSE-RUN VIADUCT; CINCINNATI SOUTHERN RY.
(Dotted lines show the old structure.)

## CONCRETE STREET PAVEMENTS AT RICHMOND, IND.

In our issue of Jan. 28, 1904, there was published a short article by Mr. H. L. Weber, City Engineer of Richmond, Ind., giving a general description of concrete pavements laid in Richmond and their cost. In our issue of Mar. 2, 1905, plans and specifications of Mr. Weber's work were given. A paper recently read before the Ohio Engineering Society, by Mr. Weber, gives further

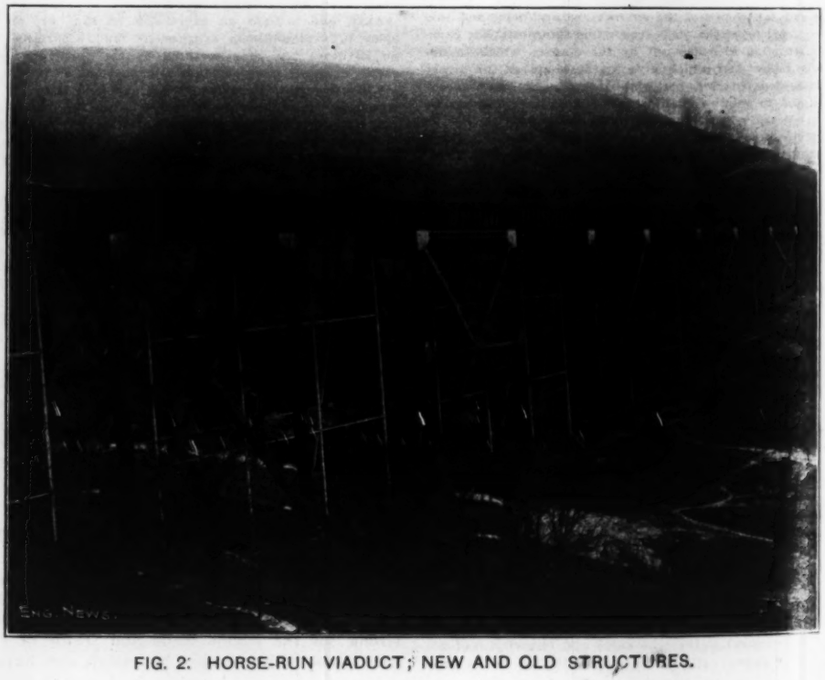


FIG. 2. HORSE-RUN VIADUCT; NEW AND OLD STRUCTURES.

information on this subject, an abstract of which follows:

How are we going to repair the concrete roadway when it begins to go into holes? I have devised a plan for making repair work easier, of which I have here a cross-section.* The foundation is laid as for concrete, asphalt, macadam, or other paved street. After that, I take a sheet of paper, light tarred paper or any kind, in fact, that will form a separating joint. The concrete that goes into the foundation should go in wet and be tamped smooth. When it is sufficiently dry we cast our sand over it. Then we take a lute, an ordinary stick about 2 ft. long cut in a bevel, outside 1 in. and inside 1¾ ins., so that when you stand up the plane of the lute is parallel with the street, and clean off the sand so none remains except in the little voids. We use very fine sand for this. We then spread the paper down and cast the concrete on top of it. We thus get the least possible space between the two concretes. The top layer of concrete is 2 to 4 ins. thick as the necessities of the case require. If there is to be heavy traffic on the street, we put on 4 ins.; if light traffic, 2½ to 3 ins. When the surface needs repairing, we break off the top layer, crush it, prepare it as before and put it back on. You will have some material left, because you must add some sand and cement; but what will it cost you? I would like to have a contract for putting it down at $1.60 per yard.

We put down one block of street about two years ago to determine the best way to lay it, what means we must provide for expansion and contraction, and how it would wear, and we made some mistakes. We put seams through it, and seams in a cement pavement are just like crevices in a brick pavement. As soon as you put a seam in you commence to dig its grave. If it were not for the joints in a vitrified brick pavement we would have a material that would never wear out. We have in our city a brick pavement laid 11 years ago, which has not cost a cent for repairs; and if it had been laid on a concrete foundation it would be virtually as good to-day as when put down. The specifications required a clean, crushed stone foundation and the sand which was put on top has, because of the constant vibration, percolated down through the stone and left the pavement uneven. The best foundation for brick is concrete and 1½ ins. of sand. For all practical purposes you can make as good a concrete from gravel as crushed stone. Where great strength is required, I would use 1 part cement, 2½ gravel, and 5 of stone. The main thing is to get a good, smooth, continuous surface, conforming as nearly with the top surface as possible, then very light rolling. Then put on the top layer of concrete, or whatever material is to be used.

Our first experience was with cement alleys. Those laid 11 years ago are just as good to-day as when put down. The traffic is confined to a space a foot wide on each side, but we see no wear except where made in blocks, and there they are chipped back. The face of the block is as good as the day it was put down.

We went to Bellefontaine to investigate the Bellefontaine pavement which has been down 13 years, but which is very unpopular there. It is a very good pavement, but the fault found is that it is too slippery. That was made, I think, of about half cement and half sand for top finish.

They trowelled their surface very hard and the consequence is it is like a piece of glass. We sent a committee to Bellefontaine to examine this pavement, and I would like to read you this committee's report:

Department of City Civil Engineer,
Richmond, Ind., August 12, 1904.

To the Common Council:

Gentlemen—The special committee appointed by your honorable body to investigate cement and brick street construction, and submit a report and recommendation for the improvement of Fort Wayne Ave., from North D. to E. St., beg leave to submit the following:

We proceded on August 10 to Dayton, Springfield and Bellefontaine, Ohio, and made a careful observation of the several kinds of improvements, including asphalt, stone, brick and cement roadway.

In Dayton and Springfield we found that the brick streets presented the best appearance and were showing the best results for the money invested, and for the period they had been in use. At Dayton we found that the brick known as fire clay had been more extensively used than the shale in the early construction of brick streets, but that the shale brick are withstanding the traffic best. At Bellefontaine, Ohio, they are putting down "Canton Shale Block," the same as those used in the construction of North E. St., this city; the brick at this point are giving general satisfaction.

It was at Bellefontaine, Ohio, that we went to inspect a cement roadway and were greatly surprised to find it so unpopular. The objection to the cement pavement was that it was too slippery; that it was as slippery in summer as in the winter seasons; this was the only objection offered, but with the Bellefontaine people it was a very serious matter.

There is no question in our minds about the wearing qualities of the cement roadway, and all we met in Bellefontaine considered that its wearing qualities were all right. We found the cement pavement at Bellefontaine was holding its own in this regard with all its competitors, in fact, it had the best of the argument. The serious mistake in laying the Bellefontaine cement pavement, to our minds, was in making the plates too small, and corrugating, the surface, thereby creating many unnecessary joints, and especially the parallel joints, the only place the pavement shows any perceptible wear; also giving the surface a steel trowel finish, which made a hard glossy surface, which we think was another mistake.

The objection we found to exist at Bellefontaine, "the slippery surface," we do not find to exist in the cement streets put down as an experiment in this city; we account for this in the different style of surface finish. The surface finish of Richmond streets is made by first trowelling with a steel trowel to insure perfect contact and solidity of pavement, and then trowelling with a cork trowel, leaving the surface in a condition representing a sandstone finish.

Our visit was a matter of great satisfaction and the means of settling doubts that existed in our minds as to the wearing qualities of the several kinds of material, and especially the cement roadway. We are convinced that for curb and gutter, sidewalks and alleyways, cement has no equal, and we believe that for street purpose it is destined to be a strong competitor in a very short time with the leading materials used for this purpose. The objectionable features, the joints and slippery surface, we believe have been eliminated in the Elm Place improvement, and will be efficiently overcome in future improvements of this kind.

After weighing all the features that exist and that will enter into the construction of the Fort Wayne Ave. improvement, and after examining the plans and specifications and samples of material submitted by the contractors, we would recommend the street to be constructed of brick, as we believe no better street for the purpose can be constructed, although one equally as good of cement might be constructed at less cost.

Wm. Alexander,
Chas. H. Sudhoff,
Edgar Norris,
Special Committee.

You must eliminate the joints in concrete roadways to avoid wearing off on the edges; and if you do that I cannot see why the concrete roadway should not be adopted over the entire country.

DISCUSSION.—Mr. Wells: May I ask what you consider the maximum allowable grade on cement pavement?

Mr. Weber: Well, we have brick streets in our place on a 5% grade. I do not think a cement street would be any worse to get up than the brick. I think we can use 5 or 6% nicely. You should cut down your crown so as not to drive the traffic to the middle of the street. When the crown is excessive the horse naturally follows over the top. I would make the cross-section very flat, just so the water will run off.

Professor Gilpatrick: What is the comparative cost of this cement roadway with brick?

Mr. Weber: You can build concrete for 33% less than brick. You can build brick for about 35% less than asphalt.

Professor Gilpatrick: What is the comparative cost of macadam or stone roadway?

Mr. Weber: Our roadways are all on good gravel foundations and we simply pick them up and put on 3 or 4 ins. of macadam. The entire cost is about 22 or 25 cts. a sq. yd.

Professor Gilpatrick: What would be the comparative first cost?

Mr. Weber: About 60 cts. a yard. It would depend greatly on your excavation. I do not believe our macadam roads cost over 60 or 65 cts. a sq. yd.

Professor Gilpatrick: Do you roll your subgrade and your first layer of concrete?

Mr. Weber: No. We generally roll the subgrade, but if it is pretty solid we do not roll it. Then we put on the first layer of concrete and tamp it.

Professor Gilpatrick: If the surface becomes imperfect and needs repair, can you pick it out and resurface, if you do not use paper?

Mr. Weber: I do not think you can do it. It is such a hard material, I do not think you can ever repair it without taking it all up.

*See Engineering News, Mar. 2, 1905, p. 215.

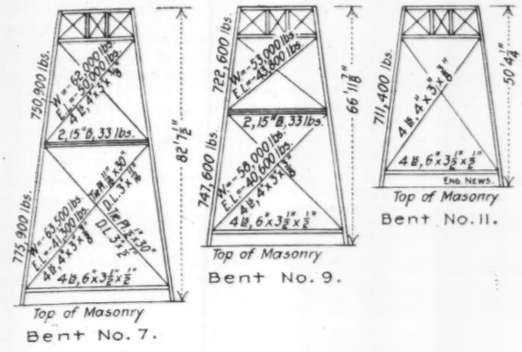



FIG. 3. ELEVATIONS OF BENTS.

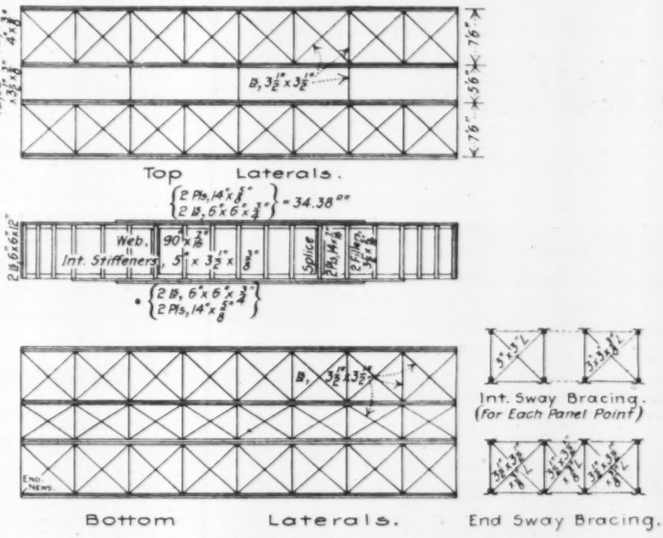



FIG. 6. PLATE GIRDERS AND LATERAL BRACING.

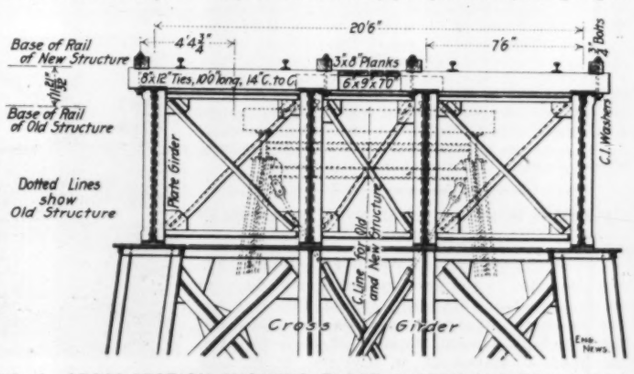



FIG. 4. CROSS-SECTION SHOWING FLOOR SYSTEM AND TRANSVERSE GIRDERS OF HORSE-RUN VIADUCT.

## NEW EQUIPMENT FOR SUBURBAN TRAFFIC ON THE CHICAGO & WESTERN INDIANA RY.

The Chicago & Western Indiana Ry. has recently established a suburban service, which had formerly been operated by the Chicago & Eastern Illinois Ry. After this latter road became a part of the St. Louis & San Francisco Ry. system some months ago, its trains were run to the La Salle St. station instead of Polk St. station, and its

suburban service was abandoned, being turned over to the Chicago & Western Indiana Ry. For this purpose special engines and cars have been built. The service is between Chicago and Dolton, 11 miles, with 15 stops; and the trains usually consist of two to four large cars.

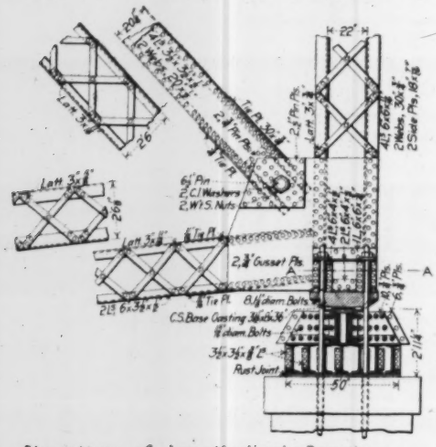
Tank engines are used, of the 2-6-2 type, somewhat similar to those of the Central R. R. of New Jersey, described and illustrated in our issue of Feb. 16. They have large side tanks, and a rear tank under the cab, with a standpipe extending up through the coal bunker. This standpipe was intended to be used for filling the tanks, but taking water in this way was found to occupy too much time (owing to the restricted flow through the pipes leading from the tank under the cab to the main side tanks). Openings have therefore been made in the tops of the side tanks. There was some little trouble at first with hot boxes on the trailing axle, which axle is carried by a radial truck frame. This difficulty has been eliminated by the use of a special composition for filling the brasses; this consists of 75% soft lead, 10% hard lead, 10% tin and 5% antimony. The engines have proved very satisfactory, and an additional order has been given to the builders, the Rogers Locomotive Works. The principal dimensions are as follows:

Suburban Tank Locomotives: Chicago & Western Indiana Railway.

| | |
|---|---|
| Driving wheels (6) | 5 ft. 3 ins. |
| Leading truck wheels (2) | 3 " 0 " |
| Trailing truck wheels (2) | 3 " 6 " |
| Driving wheelbase | 14 " 0 " |
| Total wheelbase | 31 " 2 " |
| Weight on driving wheels | 130,000 lbs. |
| " on leading truck | 20,000 " |
| " on trailing truck | 40,000 " |
| " total | 190,000 " |
| " of water in tanks | 30,000 " |
| Cylinders | 18 x 26 ins. |
| Valve gear | Link motion; balanced slide valves |
| Boiler, straight top, diameter | 5 ft. 0 ins. |
| Firebox | 102 x 66 ins. |
| Tubes, 249, diameter | 2 ins. |
| Tubes, length | 13 ft. |
| Heating surface, tubes | 1,695 sq. ft. |
| " firebox | 146 " |
| " total | 1,841 " |
| Grate area | 47.8 " |
| Ratio of tube heat. surface and grate area | 1 to 36.2. |
| " total " " | 1 to 39.3. |
| Coal capacity | 5 tons. |
| Water capacity | 3,500 gallons. |

The cars for this service are of special design, and have seating capacity for 100 passengers each. There are 46 seats, with reversible backs (but no side arms), and four fixed transverse seats against the ends. The seats are closer together than in ordinary cars, being spaced 33¼ ins. c. to c.; but this is found to be sufficient in this class of service, with short runs. There are no toilet rooms, and hand baggage is provided for by a continuous baggage rack on each side. The cars are of wooden construction, with some steel bracing at the ends, and are mounted on four-wheel trucks having wooden frames. The platforms have steel non-telescoping frames, and are not vestibuled. The cars are equipped with the Pintsch gas lighting system and the Gold direct system of steam heating. They were built at the shops of the American Car & Foundry Co., at St. Charles, Ill., and have the following main dimensions:

| | |
|---|---|
| Length over end sills | 70 ft. 0 ins. |
| " platforms | 77 " 1¼ " |
| Width over side sills | 9 " 8 " |
| Truck wheelbase | 8 " 0 " |
| Distance c. to c. of trucks | 56 " 6 " |
| Wheels, diameter | 3 " 2 " |
| Weight | 82,200 lbs. |
| Dead weight per passenger | 822 " |



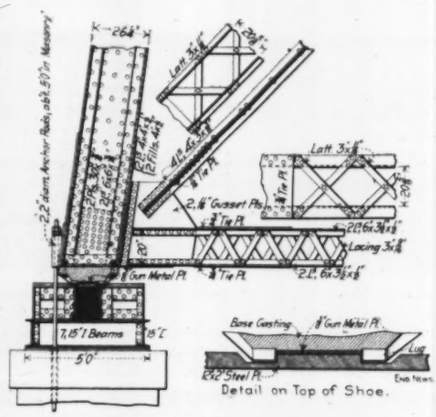




FIG. 5. DETAILS OF SHOE BEARINGS OF TOWER LEGS.

THE COPPER PRODUCTION of the United States is about 60% of the total production of the world, according to a bulletin of the U. S. Geological Survey, prepared by Walter Harvey Weed. The value of the United States output of copper for 1904 is estimated at 783,000,000 lbs., valued at $95,000,000, and dividends were declared by 17 copper mining companies to the amount of $26,161,000. There was an increase of about 8.6% over 1903, due mainly to producers in Arizona and Utah. The figures show that the Lake Superior district can barely maintain its relative part of the average increase in the production and consumption of copper, that the same is true of the Montana mines, and that the Arizona mines show a still greater increase and are likely in the near future to take the lead in the world's production. At the present time the Boston & Montana mines of Butte are the greatest producers in the world. After them in productiveness come the Anaconda, Lake Superior, and Rio Tinto mines, named in the order of their importance.

## CONDITIONS IN RUSSIA AS SEEN BY AN AMERICAN ENGINEER.

For two years past an American company has been engaged in the development of iron deposits in the vicinity of Mariopol, Siberia, the work being in charge of American engineers. Last fall the Assistant General Manager of the enterprise, Mr. John A. McDonald, M. Am. Soc. C. E., was shot and killed by a Russian Colonel of Engineers, because Mr. McDonald asked that a receipt be given for some iron which the aforesaid Colonel wished to take away from the works. The writer of the letter printed below, Mr. Chas. Francis, M. Am. Soc. C. E., the General Manager of the works, was put in a Siberian prison, but was afterward released through the efforts of the American Ambassador, and returned to the United States. At our request Mr. Francis has prepared for us the following brief article descriptive of conditions in Russia and Siberia as he saw them. With such conditions as those described by Mr. Francis, the cause of the succession of Russian defeats in the present war becomes apparent.

The present situation of Russia concentrates on that country the attention of the civilized world, and the notes of one who has resided there for two years must be of interest to the readers of Engineering News. In the first place, all Russian business is more or less subject to military rule, and thereby very much hampered. Nothing whatever can be done in carrying on business except with the sanction of a military official of some rank, and corruption among these officials is rampant in every grade. As a result, Russia is permeated through and through with graft. In Siberia the situation is, if possible, worse. There, if you raise objection to the autocratic grafting of officials, your liberty, and even your life, is not secure. I speak with practical knowledge of the facts, as I spent two years at Mariopol, Siberia, in charge of the interests of an American concern of large importance, and had daily to stand the arrogance of officials of all ranks, from the lowest to the highest. Pillaging, grafting, drinking and other immorality seem to be their only object in life.

Generally the officer is well educated, and shows to a tremendous contrast with the peasant, who is the most ignorant and bestial human being it has been my luck to come across. These live in huts, where air and cleanliness are unknown quantities. All sleep and live in the same room; their habits are worse than the beasts. To cap all these deficiencies, the excessive use of vodka, a drink closely resembling the English gin, puts the finishing touch to the demoralizing life of this people.

If this abuse of alcohol were confined to the uneducated class of Siberians and Russians it might not be so bad, but the educated class is as badly addicted to drink as the peasants. Several times last November I visited General Kuropatkin's camp, and could easily understand the reason why the mighty Russian army was invariably badly beaten by the Japanese. Each time I was there I saw drunken men everywhere. Soldiers and officers alike were absolutely incapable of acting. You cannot imagine the disgusting revelry and bestial immorality in that army.

There have been many inquiries as to the condition of the Trans-Siberian Railway. I have seen very poor railways in Africa, but I have never seen a permanent way in such a disreputable state as that of the Trans-Siberian. Not even at important stations have attempts been made to keep it in proper shape. When you see the road in such bad repair, while piled along the track is enough material to build a double track over the entire length, and you see this very material falling into decay and rust without any attempt to prevent it, it sets you wondering. The explanation is given in one word: Graft. The country through which the Trans-Siberian passes is very rich in minerals, but no other than Russian subjects have the right to exploit the riches of the mines. I located rich mines of brown hematite, and also mines of anthracite coal, near Mariopol, toward the Manchuria line. A little way northwest I located a very rich and important deposit of gray hematite. By heavily bribing the then governor of this province I obtained for my firm the authorization to exploit these ore deposits, but the exorbitant demands of this man and other functionaries compelled us to stop.

This is not an isolated experience, for to my personal knowledge the same thing has happened eleven times in the last two years. The Russian officials will encourage foreign capital to establish a plant, and then, on one pre-

Fig. 7. Erection of New Viaduct from Old Structure.

text or another, they will seize the plant, and, so far as they are able to, exploit it themselves. If you object, they put you in prison, and are not slow to use the knout and to confiscate your personal property on the fallacious pretext of political reasons. I am preparing a detailed report which will give exact data as to the chance of foreign investments in Russia and Siberia. But in the meantime, I would advise everyone intending to do business there to take great precautions.

Yours very truly,

Chas. Francis de Nevers,

M. Am. Soc. C. E.

345 West 56th St., New York City, May 26, 1905.

# ENGINEERING NEWS

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The municipal revolution at Philadelphia promises to be more successful and far-reaching than any one dared hope at the outset. On Thursday, June 1, the gas lease extension ordinance was unanimously withdrawn by both branches of Councils to forestall the Mayor's veto, and that action was followed in select council by the unanimous approval of Mayor Weaver's appointees to succeed the men whom he removed from the offices of director of public works and public safety. Councils have also reconsidered some of the bills passed over the Mayor's veto on May 18, in apparent defiance of his threat to veto the gas extension lease ordinance.

The Mayor has taken steps to review the capital expenditures on the gas works, which the city must repay if it resumes control of the works in 1908; he and his supporters are looking into the street railway franchises put through so hastily four years ago; the police force is being investigated; the assistant directors of the departments of public works and safety have been replaced by long-time bitter opponents of the "organization;" and the mayor has announced that he is not going to stop until he has swept the city clean, and that he is willing to give his life to the work. With such a beginning, such determination and with the public support given him bright days appear to be in store for Philadelphia.

The bondage of the city to private and "organization" interests can scarcely be appreciated by an outsider, if indeed it is yet fully grasped by most Philadelphians. To name only one instance in addition to the gas scandal: The notorious street railway legislation of four years ago gave away franchises on practically every available street in the city, but provided for a forfeit in case construction was not carried out within five years. The last legislature, with the approval of Governor Pennypacker, a former judge, authorized the abandonment of franchise rights in streets and agreements with the street railway company to exclude all other companies from those streets for fifty years. Four of the nine bills passed over Mayor Weaver's veto on May 18 authorized contracts of this nature. At any other time in Philadelphia, one would suppose, and at any time in any other city, such acts would not have been tolerated by the public, but they were almost lost sight of during the gas lease excitement. It is gratifying to note that they are now to receive attention and that in addition steps are to be taken to secure compensation, in one way or another, for the valuable privileges flung into the lap of the street railway interests a few years, at a time when would-be rival bidders offered $2,000,000 for the franchises. The first plan announced is a proposed ordinance which, it appears, would require a change from overhead to underground trolleys.

The fight at Philadelphia has been watched with intense interest in other cities of the United States and the success of the reformers there will serve as an example and an encouragement elsewhere.

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When an elastic body is subjected to stress it is deformed in a measurable and more or less exactly calculable manner. The forces causing the stress must perform work in producing the deformation, and the work thus expended is stored up in the body and may be returned by it. In nearly all our constructive materials this property of energy storage is not made use of, but is, if anything, undesirable; in certain others, however, it is directly employed, such bodies being called springs.

Ordinarily, in thinking of spring action in the case of the highly elastic materials, such as tempered spring steel, we think of the phenomenon as completely reversible—as an action involving no loss of energy in the production of heat. This view is unquestionably an error in most, and probably in all, such cases. The initial deformation of the body produces sensible heat in the body, which leads to the inference (but does not *prove*) that the corresponding amount of work is not recoverable. When the spring returns its stored work, there is undoubtedly also a thermal action, though, as far as we know, its nature has in general not yet been studied. Analogy with other actions, such as the compression and expansion of gases, suggests that there is a measurable difference between the force-relations on distortion and those on recovery.

At the Railway Appliance exhibition held at Washington during the first two weeks of May, a bit of evidence on this point appeared in one of the exhibits. The exhibitor of a friction draft-gear for railway cars showed indicator cards—that is, stress-strain diagrams—over a complete cycle, taken from a friction draw-bar and a spring draw-bar. The former, as might be expected, showed a very full card representing a large absorption of work (by an irreversible process). The card taken from the spring draw-bar, on the contrary, showed an exceedingly narrow diagram, indicating that almost all the energy stored during the compression of the spring was again given out on recovery and would remain in the train, causing a series of shocks to travel through the coupled cars; however, it did show a measurable area, the line of recovery being not absolutely coincident with the distortion line, and this area represented a loss of energy which undoubtedly went to heat the material of the spring.

Theoretically the question of loss of energy in springs is of very great interest and has a very broad range; it involves a number of considerations that at present barely appear in the study of materials. From the practical side the question is also of much importance: we should be able to foretell the energy loss—that is, the heat production—in any given spring under any given service. In some cases, where springs are used the loss of energy is important in itself. In other cases, the heating of the spring is the important point. The question was put to us recently by an inventor and designer who was engaged in working out a special mechanical problem, whether, in the case of a spring which he planned to put to a definite use where it would be exposed to practically continuous cycles of deformation and recovery, any danger of undue heating existed. We were compelled to reply that, while there was little probability of any serious heating with a spring that would otherwise prove suitable for this purpose, there was absolutely nothing in theory or experimental observations to guide us in making an estimate of the heating effect.

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A practical illustration of a device involving the same mechanical principle is the Pope spring-sprocket for motor bicycles, illustrated on another page of this issue. In this device, springs are placed between the working crank and the driving sprocket of a motor bicycle and are alternately compressed and extended at every stroke of the motor. The question at once arises: What is the "efficiency" of the spring? What percentage of the energy applied to it to compress it does it give out when it extends? So far as we have been able to find, none of the standard treatises on elasticity and resistance of materials give any information on this point. In nearly all cases where springs are used in mechanics their compression and extension is intermittent and not at all rapid; but here are springs which are alternately compressed and extended perhaps a thousand times a minute. If these springs absorbed even a fraction of 1% of the energy applied to them at each stroke and converted it into heat, they would almost certainly soon get so hot as to lose their temper.

It seems to us that the question above set forth is worth the attention of some of the bright young men in the physical laboratories of our engineering schools who are searching for new fields of knowledge to exploit. It would be a comparatively simple matter, we judge, to transmit power through a spring and measure either the loss of power, or else the heating effect produced. Another method of experimenting would be to place a weighted spring in a vacuum tube and observe the rate at which the vibrations of the spring were checked.

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Our British contemporary, the "Surveyor and Municipal and County Engineer," reprints our editorial on the systematic disposal of garbage by burial, published in our issue of April 6, and gives a qualified approval of the plan. It expresses itself as still unconvinced, however, that such a system could at all compare with the cremation plan of garbage disposal, or, as it calls it, "the very much cleaner and more wholesome method of burning."

We shall freely concede to our contemporary that under the conditions existing in the great majority of cities and large towns, cremation is the most practicable and satisfactory system of garbage disposal that can possibly be found. In most places in Great Britain and in a great many cities in America it would not be practicable to obtain land for the land burial system on any reasonable terms. There are, however, many parts of this country where land can be bought or leased on moderate terms within easy reach of cities of considerable size. It was for such locations as these that we advocated the land burial system for the disposal of garbage.

In such locations we are still strongly of the belief that the absence of dust and smoke and other attendant features of a garbage crematory might make a land disposal system even preferable to a cremation plant, on the very grounds of cleanliness and wholesomeness, on which our contemporary lays stress.

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## WHAT WILL BE THE FUTURE RAILWAY TRACK FOR HEAVY TRAFFIC?

Half a dozen years ago, in our issue of Jan. 5, 1899, there was published an article and an editorial proposing a permanent track construction for steam railways of heavy traffic, embodying longitudinal concrete supports for the rails, and presenting detail designs for a track construction of this sort.

In view of the amount of time, labor and money which is being expended by hopeful inventors and their financial backers in the development of various forms of concrete cross-ties, reinforced concrete cross-ties and steel cross-ties, it seems well worth while to return to the subject again. By way of illustration we may note here that at the recent Railway Appliance exhibition at Washington there were four different exhibitors of concrete ties and three exhibitors of steel ties, and only one exhibit of a concrete longitudinal track construction. Yet there are very strong reasons for believing that when the time comes that the present makeshift track construction which we

miscall "permanent way" is displaced by something really permanent, it will be a longitudinal system rather than a cross-tie system.

In view of the present practically universal use of wooden cross-ties in railway track, it may seem extravagant to predict so radical a change; but to engineers who are aware how widely and successfully the longitudinal system of rail supports has been used, the proposal will not appear by any means revolutionary.

For a great many years the longitudinal system was the standard track construction on the Great Western Ry. of England; and it is still in place on a good many sidings on that railway. In Germany for a long time the longitudinal system was in nearly as extensive use as the cross-tie system.

It is important to note the reasons which led to the longitudinal system being abandoned and the cross-tie system substituted. These were, first, the difficulty in draining the space between the rails. The ballast under the longitudinals sometimes became packed so that water would not freely escape through it to either side, but would soak in and soften the subgrade. Second, the necessity with the longitudinal system of providing tie-bars to hold the rails to gage. Third, with wooden longitudinals, which sooner or later decay and have to be removed, it is quite a difficult matter to take a defective timber out of the track and replace it with a new one, on a busy road, where such work must be done between trains. Indeed, we are informed that this last consideration was more important than any other in bringing about the change to cross-ties on the Great Western Ry. Fourth, with wooden longitudinals there is more difficulty in placing the rail supports on sharp curves than with the cross-tie system.

But with a system of concrete longitudinals of substantial and permanent construction, the reasons above set forth for preferring cross-supports for the rail to longitudinal supports, nearly all disappear. It is as easy to form concrete to a curve as to a straight line. The concrete support being permanent, facility of removal for repairs will be no longer of any importance. Tie rods to hold the rails to gage will indeed be necessary; but can be easily applied at very small expense. It needs, therefore, only provision for drainage of the space between the rails to eliminate the reasons that originally led to the laying of rails on wooden cross-ties instead of longitudinal timbers.

Let us add here, however, that still another controlling reason for the use of cross-ties in the pioneer days of railway construction was their very small cost. On most of the early American railway lines, for example, cross-ties were cut and hewed to shape in the forests adjacent to the line and were furnished ready for laying at a cost of a few cents apiece, far below the cost at which sawed timber longitudinals could have been furnished. Actually, the cross-tie system belongs to the pioneer days of railway construction and the period when the primeval forests of the world have been exploited with as little thought of the future as if they could forever continue to pour forth an inexhaustible supply of timber products. That period, we need hardly say, is fast approaching its end.

There is another very important reason why a change from the cross-tie system to the longitudinal system is well nigh certain to take place whenever a change is made from a wooden rail support to one of steel or concrete. In the cross-tie system the rail rests on a series of independent supports, and it is a practical impossibility to give each of these supports exactly the same foundation, or in other words, to tamp them all exactly alike. The elasticity of the wooden cross-tie compensates for the imperfections of the track gang's work. The tie is compressed under the wheel load a considerable fraction of an inch, and if one tie is tamped harder than the others it is compressed a little more; or if it is more lightly tamped, a part of its proper share of the load is distributed to the ties on either side.

Thus the wooden tie lends itself admirably to the cross-tie system of construction. Its elasticity serves to compensate for the unavoidable imperfection of the track gang's work. But suppose we substitute steel or concrete ties or independent supports in place of the wooden ties. These materials have no such large range of elastic motion as the wooden tie, and there can be no such distribution of the load with ties unequally supported. If a steel or concrete tie is lower than its fellows on either side, its load will go to them, and the rail must bridge the whole width of the gap. Conversely, if a steel tie is tamped high, it will receive the entire wheel load. The result is an uneven riding track, kinked rails and rail bases cutting into or crushing the ties.

Of course, by careful track work these conditions can be minimized; and it is well known that steel ties and even cast-iron ties have actually been extensively used for years in some parts of the world; but what we want is a system that will reduce the present excessive amount of track work, not one which will require greater labor and expense than the present system to keep in order. It may be said that steel or concrete ties when once bedded would be more permanent than wooden ties, as they would not be subject to decay; but it is an inherent defect of the cross-tie system that the rail supporting structure is too shallow. An engineer would never design an important building and support it on wooden blocks bedded a few inches below the ground surface; and he would not consider the case much better if stone or concrete blocks were substituted for wooden. To make a permanent support for railway track we must carry our foundation course down deeper, just as we would a building foundation. But it is practically impossible with the cross-tie system to make the foundation much deeper than the thickness of the present wooden ties, for the trackmen could not reach under the ties to tamp them if the ties were, say, 12 to 16 ins. in depth. There is not room enough between the ties to permit this; and it is, of course, out of the question to space the ties farther apart. All this points directly to the replacement of cross-ties with longitudinals whenever a really permanent system of track foundations replaces the present "mud sill" system.

Referring again to our proposal of half a dozen years ago for concrete longitudinals, we note with interest support for this idea in a recent editorial in our contemporary, "The Railroad Gazette," entitled, "The Track of the Future." We quote at some length from it as follows:

> When the supply of timber for cross-ties becomes exhausted or the cost of good wooden ties becomes too great to warrant their use, what form of track support will the railroads adopt as a substitute for the wooden cross-tie system? . . . .
>
> Whatever cause may lead to the final abandonment of the cross-tie system, its successor will probably be some form of continuous support. The arguments for and against the principle of continuous rail support are familiar to the practical railroad man and need not be even reviewed here. It seems to be generally conceded that if some satisfactory form of longitudinal continuous support could be devised, the cost of which would compare favorably with the cross-tie system, it would meet with a prompt and hearty reception. There seem to be substantial engineering and economic reasons for believing that this track of the future will have for its support some combination of steel and concrete. For supplying permanent bearing surface on the roadbed, concrete seems to be the most promising material, while for supplying the strength and rigidity of the beam element, nothing is likely to rival rolled steel sections. Whatever the combination may be, the ballast course intermediate between the structure proper and the earth roadbed will doubtless be retained. Its superior capability to promote drainage, to distribute load and to supply a certain degree of elasticity to the track are likely to make it an indispensable element in the future as it is now.
>
> If a guess at this track of the future were to be hazarded, it would probably be as follows: It will be a longitudinal continuous bearing system. Upon strips of ballast sufficiently wide and deep will rest, under each rail, a concrete beam wide enough to supply ample bearing area, and 12 to 16 inches deep. It may or may not be steel-reinforced. Upon this concrete will be placed a rolled steel I-beam of special section not less than 10 ins. deep, and weighing not less than 50 lbs. per ft. Its bottom flange will be wide enough to supply sufficient bearing upon the concrete, or such width will be secured by a plate riveted to it, and its top flange will be wide enough to carry the special rail and its fastenings. It will be secured to the concrete by anchor bolts. The two beams—one under each rail—will be securely connected by tie-struts having sufficient vertical stiffness to hold the beams securely upright. The rail will differ radically from the present section, because its function will be different. Substantially, it will be a strip or bar of high grade or special metal having a section that will permit secure fastening to the I-beam. It may be considered as the present rail section with the web eliminated, the foot greatly reduced in width. It need not weigh the heaviest service more than 50 lbs. per yd. Its office will be to guide the wheels, and to take the wear on the flange and tread. Its light section will permit it to be properly worked in manufacture, and its special quality will make it very durable. When worn out it will be renewed without disturbing any other part of the structure, and at relatively small expense. The foundation of such a track structure will be below the necessary frost line and its stability and permanent character will largely prevent the track, when once in place, from shifting in line or surface. Track heaving by frost will be the usual shimming should be entirely avoided. Slight adjustment will occasionally be necessary and the problem of how such adjustment may be made when required will occur to the trackman as a very difficult one. Powerful track jacks, taking hold under the concrete beam, would raise the structure without serious difficulty, and slotted anchor bolt holes in the flange of the I-beam or its foot plate would permit of lateral adjustment. There would necessarily be many details to work out before the system reached a high degree of excellence, but these details ought not to be very difficult, and certainly not impossible. They need not be taken up here.
>
> Such a track structure should be superior to that now in use in many particulars. When once properly put in place it should be as permanent as the steel and concrete of which it is made, and, excluding the rail proper, we might reasonably expect a life of twenty-five or thirty years. The durability of the rail would be a function of the tonnage, and when worn out, new rails could be substituted with great facility and economy, and the waste of metal in the wornout rail would be comparatively small. The advantages of continuous support would be secured, and the track when once put in perfect line and surface should remain so with little adjustment or repair for a long time. The cost of track repairs should, therefore, be greatly reduced under even the heaviest tonnage. Other merits and demerits which will readily occur need not be here discussed.
>
> Taking up lastly the cost of construction—the consideration which the railroad will usually place first—a rough estimate at present prices indicates that the cost would be large—so large as to make it prohibitory now. It would probably be in the neighborhood of $25,000 per mile of single track. Of course the present day railroad man will exclaim, "Preposterous! The project is not worth a moment's consideration!" Certainly it is not worth a moment's consideration at this time. Even if it might be shown to be more economical in the long run than our present system, it might not be possible to secure the capital required for its installation. The value of its consideration now lies wholly in showing how chimerical it is at the present time to discuss systems of permanent track construction designed to take the place of our present cross-tie system. The construction here outlined is not ideally too good, and it is very doubtful if any system of permanent track construction that will be good enough can be devised that will cost much less than the figures stated.

We cannot agree with our contemporary that the project which it sets forth is "not worth a moment's consideration at this time." On the contrary, we happen to be aware that a well-known civil engineer, very closely connected with a leading railway company, has recently made detailed plans for some such track construction as our contemporary proposes. It is well understod that for the heaviest class of traffic the heaviest track of the present type leaves much to be desired.

Apparently, our contemporary is frightened at its own estimate of cost; but we are of the opinion that its estimate is far too large. For our own design of half a dozen years ago the estimate of cost per mile exclusive of the rails was about $6,000. This did not include the rolled channels between the rail and the concrete; but if these weighed 150 lbs. per yd., their cost at 1¼ cts. per lb. would be only $3,300 per mile.

Our contemporary has in mind apparently a heavier type of substructure than that which we proposed; but it is not at all clear that such an excess of material is needed. The office of the concrete beam under the rail is to distribute the wheel load to the earth of the subgrade, and it is an easy matter with concrete longitudinals to reduce the maximum load on this earth to not more than 2,000 to 3,000 lbs. per sq. ft., which is far below the pressures imposed by the wooden cross-tie system.

As our readers are aware, concrete longitudinals as supports for electric railway rails laid in paved streets are now generally admitted to be far superior to the wooden cross-tie system. If any precedent is needed for the use of such a sys-

tem on steam railways, this should certainly afford good assurance of success.

Let us turn next to the proposal to use what is practically a compound rail as a superstructure on the concrete support. It will certainly be conceded that the proposal deserves careful consideration. If a rail can be made with the head or wearing surface separate from the body, so as to diminish the amount of metal necessarily scrapped when rails are renewed, a great saving would result. This, however, is substantially the same argument that has been used for the many compound rails which have been invented, none of which have ever attained commercial success. That the change from perishable wooden crossties to permanent concrete longitudinals as a support may make possible the success of a compound rail will, of course, be conceded; but the difficulties in the way are certainly very great.

On the other hand, it is easy to see that the change to a longitudinal support might bring about radical changes in the present standard rail sections. For example, with cross-tie supports the most important requisite in a rail is stiffness. The rail is a girder bridging the space from tie to tie. The late A. M. Wellington used to point out that the stiffness of rails increased as the square of the weight per yard, and strongly urged the use of heavy rails to make a stiff and unyielding track.

With wooden longitudinals there is still need of stiffness in the rail on account of the great compressibility of wood; but if we support the rail on a continuous concrete girder which is practically unyielding and far stiffer than the deepest girder rail ever rolled, there is no longer necessity for designing the rail as a girder. What we then want in a rail is a head to take the wear and a base wide enough to transmit the load to the concrete without exceeding safe stresses per unit of bearing area. Of course, the necessity of so designing a rail that a strong and durable joint can be made, must be borne in mind, and the necessity of securing tie-bars to the rail and of fastening it immovably to the concrete is to be considered. We are not attempting here to design a rail section to fit these requirements, but to point out that the track of the future may very possibly rely on concrete rather than steel for longitudinal stiffness, and need not necessarily require the very large amount of metal and the great expense for construction assumed by our contemporary.

## LETTERS TO THE EDITOR.

### Exterminating Weeds in Paved Streets.

Sir: In answer to an inquiry in Engineering News of May 25, 1905, in regard to the extermination of weeds in city streets and sidewalks, I would say that my experience with the obnoxious pestilence suggests a little exertion on the part of property holders.

Very truly yours, B. M. Laughead.

Copen, W. Va., May 27, 1905.

(There are cases where either local usage as to the care of public streets or else stretches of unimproved property make it necessary for municipalities to cope with the weed problem. In Colonial cities or towns, it is likely that native property owners could not readily be induced to keep down the weeds, even if the task were not very difficult.—Ed.)

### Indefinite Sewer Specifications.

Sir: A client of mine recently submitted to me a sewer specification and contract involving something like $50,000, requesting me to go over and verify his figures. In reading over the specifications I found them to contain clauses such as the following:

The engineer in charge shall generally interpret the specifications and detail plans at the work, but should any question arise as to the true meaning, the decision of the Sewer Committee shall be final, binding and conclusive.

The contractor shall keep the entire work covered by these specifications in complete repair against leakage, breakage, settlements, etc., for a period of three years after the final completion and acceptance of the contract.

All timber used shall be drawn as the refilling progresses, unless when specially ordered to be left in place. No extra charge will be allowed in either case.

To determine the value of work under such specifications required a greater knowledge of the laws of probabilities than I possessed, and I felt compelled to decline the fee in fairness to my client. While contractors are willing to bid upon such chances, is it any wonder that litigation, abandonment of contracts, and trouble on public work is the result? Such specifications admit of too wide interpretation to allow conservative or safe bidding, and are in the end usually detrimental to the town itself.

Alexander Potter, Consulting Engineer.

143 Liberty St., New York City, May 26, 1905.

### An Argument Against the Alliance of M. I. T. with Harvard.

Sir: The writer, as an academic and a technological graduate of two eastern institutions, has followed with considerable interest the proposed scheme of alliance or consolidation between Harvard University and the Massachusetts Institute of Technology, but so far without forming any very definite opinion on the subject, until after reading the letter of "M. I. T. Alumnus," published in your issue of May 25, with the views presented in which I am strongly disposed to agree.

The motif of this whole movement seems to be, on the one hand, a sort of imitation of the methods of what is called "high finance" or commercialization of education (to save money and bring in money, according to your correspondent); and, on the other hand, a reflection of what is occurring in Germany in the same direction, where it seems that the universities are also trying to corral technical schools. It is a fact, applying, I suppose, as well to this country as to every other, that so long as the applied sciences were in their infancy, they and the schools that taught them were looked upon by the universities with a kind of condescending scorn, after the manner of Fitz-James—

"Moves our free course by such fixed cause
As gives the poor mechanic laws?"

It is a fact that so late as I was a student in my academic course, I can remember an eminent Yale professor speaking of Stevens Institute and others of its class with scorn as mere "manual training schools," and I believe that this was not far from being the general view held at that time among the university faculty.

Now, however, that the applied sciences are assuming a role of greater importance, and are beginning not only to draw patronage from, but even in some ways to overshadow the universities, the latter seek to gather them in, as it were, and make them a part of the institutions of universal knowledge, of which they are supposed to hold the keys.

The technical schools of Germany are not unnaturally averse to any such consolidation as that proposed by the universities, for they see in it merely their own absorption and ultimate practical extinction, to which they would begin to tend so soon as they come under the influence of the university faculties. The universities say in effect, "We offer you the prestige of our world renowned institution and a university degree," to which the schools reply, "Twenty years ago we would have been glad to have your degree, but now we feel ourselves better off without it. We are institutions per se." Such at least is the tale as I received it from a German engineer. It would be interesting if some of your readers who are familiar by actual experience with the German situation, should communicate what they know on the subject.

However this may be, I am convinced that there would be nothing gained, generally speaking, by consolidating technical schools with the universities. They are indeed both educators, but the object of the education is and must necessarily be diametrically opposed. The object of education in a technical school is a strictly commercial one, that of the university is, or should be wholly non-commercial. This being so, they must have, and as a matter of fact they have, faculties neither of which are fitted to govern the other. Perhaps the law and medical faculties are not sufficiently removed in the nature of the professions from the academic ideal to be injured by the academic rule. Not so, however, the professions of the engineer, chemist and practical scientist. I feel convinced that, however semi-independent the faculty of a technical branch of a university may be, the overshadowing influence of the academic university corporation must exercise a pernicious and antagonistic influence to its proper development, and that it practically does so is a matter of easy observation to those familiar with schools which are so governed. Technical education is, and of right ought to be, an eduction per se, and left free to develop on its own lines independent of academic influence. The engineer besides ought to know that he has nothing to gain by admission to academic circles, as he must fall into the subsidiary place of a novus homo, whereas we engineers contend that our profession stands on a level with that of the other professions, a contention which, in a few more decades, I think is likely to be realized as fully practically as theoretically.

So far, then, as the Massachusetts Institute is a technical body, I believe that it would be entirely right in refusing to ally itself with the older institution. To this particular case, however, the above reasoning will not fully apply, because though originally a technical institution, the institute has broadened itself so as to be a kind of a university in itself, as intimated by your aforesaid correspondent. Hence, there arises different considerations, which require to be settled on a different basis, and which I will not undertake to discuss, although I may remark that even though it is no longer strictly an institute of technology, it does not follow that two institutions, any more than two individuals, in the same line of business, but having different ideas and ways of doing things, will benefit the community by combining themselves and their distinct individualities into one.

George W. Colles.

Milwaukee, Wisconsin, May 27, 1905.

### Notes and Queries.

The Virginia Sand and Gravel Co., Norfolk, Va., desire to purchase some cement high in magnesia and requests the address of some cement manufacturer who can supply it.

## A FIREPROOF WHARF AT TAMPICO, MEXICO.*

By E. H. Connor,† M. Am. Soc. C. E.

Tampico, the largest port in volume of traffic in Mexico, is situated on the Panuco river about six miles from its mouth. The Panuco empties into the Gulf of Mexico about 250 miles below the mouth of the Rio Grande, the southern extremity of the United States.

In 1890 the Mexican Central Railway Company, under contract with the Federal Government of Mexico, built stone jetties at the mouth of the Panuco in order to remove the obstructing bars and furnish a safe passage for ocean vessels of deep draft. This work, done under E. L. Corthell, M. Am. Soc. C. E., was very successful and maintains a channel about 28 ft. deep over 500 ft. wide. The usual range in tides is only about 15 ins., a matter of great importance to maritime commerce.

During the years 1900 to 1902 inclusive, the Mexican Central Ry. under contract with the Mexican Government built a finely equipped, steel concrete, fireproof wharf at Tampico, at which the largest vessels can land.

The purpose of this article is to describe this wharf.

Under a similar arrangement, a fine custom house, and along its front a creosoted timber wharf, was built in 1897, but the wharf caught fire just as it was completed, and was burned to the water line. Of course the creosoted piles were uninjured below the water line, and these were considered in a subsequent study for a new wharf.

In July, 1898, the Mexican Central Ry. Co. employed the late A. J. Tullock, of Leavenworth, Kan., M. Am. Soc. C. E., as engineer to investigate and report on the subject of a fireproof wharf. Mr. Tullock selected Mr. Alfred Noble, M. Am. Soc. C. E., of New York, as consulting engineer to aid him in this work. An engineering party was organized and sent to Tampico to make borings and carefully investigate the conditions existing there. Careful study was also made at the same time of wharves built in this and other countries, and of the various features governing their design.

Fifty-one deep borings were made, ranging from 60 to 100 ft. deep. Fine silt or mud was found to a depth of about 50 ft. below mean high water, underlying the silt, clean, fine sand. Many tests were made to determine the supporting power of piles driven in this material. Numerous designs and estimates were made of a wharf for this particular location, but only three were recommended by the engineers in their exhaustive report, and in the following order as to merit:

(1) A concrete quay wall extending along the face of the wharf its entire length with earth fill between the wall and the custom house. The concrete wall to rest on pneumatic caissons sunk into the clean sand.

(2) A superstructure of steel beams and concrete arches resting on steel cylinders with piles driven inside and filled with concrete.

(3) A superstructure of steel beams and concrete arches resting on cast-iron water pipe sunk around the piles of the old wharf and filled with concrete.

Design No. 2 was approved by the Mexican Government as best combining the properties of supporting power, durability and economy. Design No. 1, would have cost much less for maintenance, but the original cost was estimated at about twice that of No. 2. Design No. 3 did not possess sufficient supporting power to carry loads desired, or if made strong enough, possessed no economy.

A concession to build the wharf was granted the Mexican Central Ry. Co. in December, 1899, and final approval of the plans and estimates given in February, 1900. Mr. Tullock was made chief engineer to prepare plans and superintend the construction, and all work was done under his direction. Mr. Noble continued to act as consulting engineer. Mr. A. B. Rose, M. Am. Soc. C. E., was resident engineer in direct charge of the work.

DESCRIPTION.

The entire wharf is 2,600 ft. long. It is divided into the main wharf and two lateral wharves. The main wharf lies directly in front of the custom house and extends 100 ft. beyond same at each end. It is 1,200 ft. long, × 75 ft. wide, and is partly covered by a steel shed 903 ft. long × 54 ft. wide. At each end of the main wharf is a

*Abstract from a pamphlet issued by the builders.

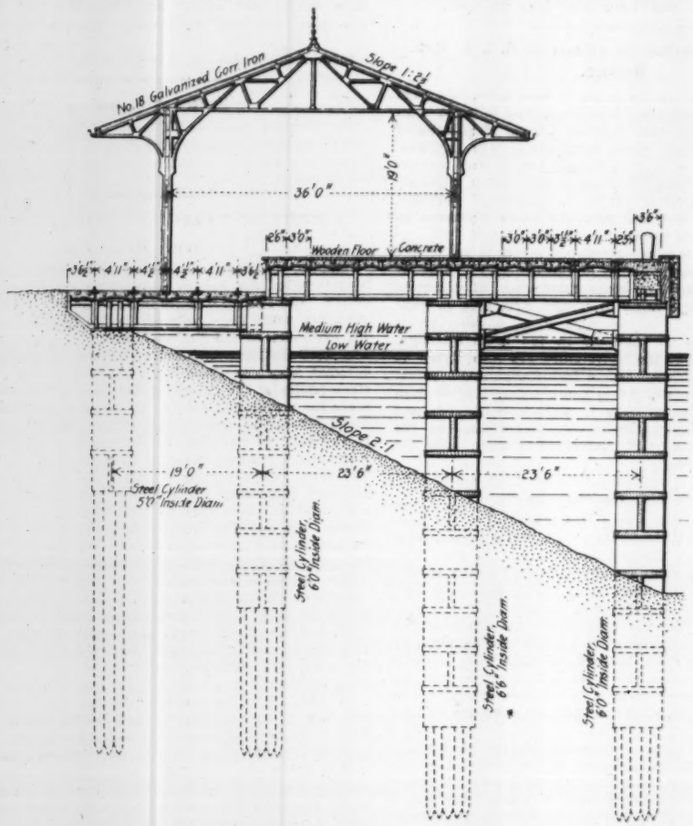
†Chief Engineer, Missouri Valley Bridge and Iron Co., Leavenworth, Kan.

lateral wharf 700 ft. long and 50 ft. wide. The lateral wharves are 3 ft. lower than the main wharf, to accommodate smaller vessels, with a grade of 4% connecting them to the main wharf.

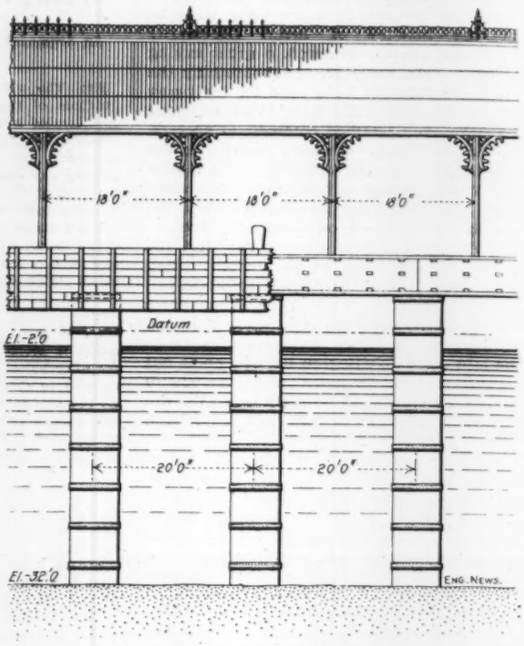
All portions of the wharves are designed to carry a minimum live or superimposed load of 800 lbs. per sq. ft. The dead load is 200 lbs. per sq. ft. on the front portion of the main wharf, 50 ft. wide, and 150 lbs. elsewhere.

A standard gage railroad track runs the entire length near the front with turnouts on the lateral wharves connecting with tracks on ballasted creosoted timber trestle approaches from the shore. The rear portion of the main wharf, 25 ft. wide, is 4 ft. 5 ins., or about the height of a car floor, lower than the front, and two standard gage tracks run on this low portion parallel to the wharf, thus making it easy for loading or unloading cars. The floor of the custom house back of the wharf is level with the front portion of the wharf. A push car track also runs the entire length of the main wharf, about 22 ft. from the face, with turntables for tracks running into the custom house. All members supporting standard gage tracks are designed to carry a locomotive weighing with tender, 139 tons, and having 88 tons on four pairs of drivers, Mexican Central Ry. specifications, 1898.

The construction of the main and lateral wharves differ in detail, and they will be described separately.

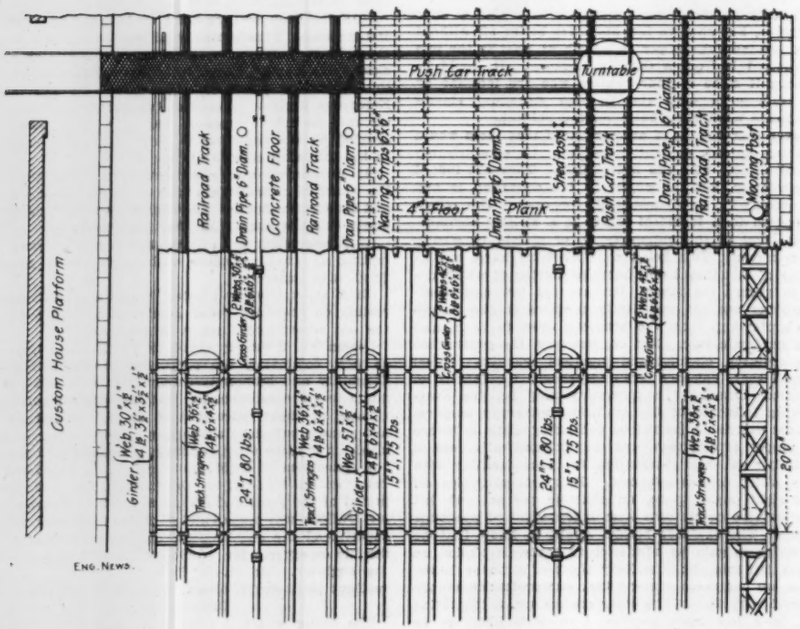



Transverse Section.




Part Side Elevation.

ELEVATIONS AND PLAN OF THE TAMPICO MAIN WHARF.




Part Framing Plan.

MAIN WHARF.

The main wharf is supported by 61 bents of four cylinders each, or 244 cylinder piers. The cylinders in each bent are spaced 23 ft. 6 ins., 23 ft. 6 ins. and 19 ft. apart, respectively, from the front, and the bents 20 ft. center to center. All piers are made of steel shells with piles driven inside of same, and filled with concrete. The steel plates forming the cylinders are ½-in. thick, except in the upper 15 or 20 ft., where they are ⅝-in. thick for additional protection, where the action of the elements is greatest.

The channel of the river in front of the wharf is 30 ft. deep at low water and the river bed slopes uniformly upward from the front to about the top of the rear cylinders, Fig. 1.

The cylinders were all made in sections 5 ft. long, butt jointed and riveted together. The creosoted piles extend below the cylinder shells distances of 15, 15, 20 and 34 ft., and above the bottom of the shells into the cylinders 27, 27, 16 and 10 ft. respectively, in the four rows beginning at the front. In all cases they go through the silt into the clean sand.

The maximum loads carried by the cylinders on the caps are respectively 150, 235, 184 and 116 tons. A heavy cast iron wall plate is partly imbedded in the concrete in the top of each cylinder to support the girders. The steel used was open hearth of medium grade, as that resists the action of salt water better than Bessemer. The piles were creosoted Long Leaf Yellow Pine. Around and between the piles were deposited concrete composed of 1 part cement, 2 parts sand and 4 parts small stone. The 4 ft. immediately above the piles, and the top 3 ft., except 6 ins., were filled with concrete of 1 part cement, 2 parts sand and 4 parts broken stone. The remaining portion was filled with concrete of the proportions 1, 3 and 6. The top 6 ins. was made of mortar, 1 part of cement to 2 parts of sand.

From the numerous tests made during the preliminary investigations, the following factors were considered safe and used in designing the piers.

| | Lbs. per sq. ft. |
|---|---|
| Bearing on sand 50 ft. below water level .... | 10,000 |
| Bearing on silt ..... | 4,000 |
| Friction in sand on sides of piles and cylinders ..... | 450 |
| Friction in silt on sides of piles and cylinders ..... | 200 |

In estimating the load on foundations, the weight of the displaced water was deducted, but the weight of the displaced earth was not. Tests made, since the piers were completed, by loading with pig iron, confirm the safety of these assumptions.

Cross girders rest on the transverse rows of cylinders. These cross girders in turn support longitudinal girders carrying the concrete floor. On account of the great shear and necessary shallow depth, each transverse girder is composed of two single plate girders, connected by diaphragms, the space between the two girders, being filled with concrete.

A box girder 42 ins. wide × 27 ins. deep, runs along the face of the wharf. This is built up of solid web plates

½-in. thick, front and rear and bottom, all connected by 6 × 6 in. angles, and is filled with concrete. The face girder of this box girder, which also supports the timber wall pieces, running along the face of the wharf, is 57 ins. deep, with ½-in. web plate, and four flange angles 6 × 6 × ⅝ ins. The timber waling pieces, 12 × 12, are secured bolted by galvanized bolts and straps to the face girder in such manner that they can be easily removed. The timbers and box girder are designed to take the wear and blows of vessels, lying alongside of or crowding against the wharf. This thrust is very great during high winds, as the entire wind force acting on a large vessel may bear on the wharf over a very short distance. Particular attention was given to the horizontal shear on these girders.

Longitudinal girders built of plates and angles, are also placed at the rear of the wharf, and at the line of change in the floor level, which girders serve as a finish for the floor, and also as longitudinal bracing.

Corrugated iron arches to act as forms were sprung between the longitudinal beams, and the concrete floor filled in on top of same, up to the level of the tops of the beams. The minimum thickness of concrete is 10 ins. at the centers of the arches. This concrete is composed of 1 part Portland cement, 3 parts sand, and 5 parts broken stone. The top and bottom inches are made of mortar, 1 part cement and 1 part sand. Nailing strips 6 × 6 ins. are imbedded in the concrete about 6 ft. center to center, and the entire wharf is covered with a wearing surface of plank, 4 ins. thick, laid perpendicular to the face of the wharf, and fastened to the nailing strips with 8-in. lag screws. Wooden strips 5 × 12 ins. were bolted to the tops of the railroad stringers, and to these are bolted the rails, with bolts extending through the top flange of the stringers, and cast washers gripping the flanges of the rails. The top of the rail is level with the top of the floor plank.

All timber is Long Leaf Yellow Pine, creosoted with 16 lbs. of oil per cu. ft. No metal less than ½-in. thick was used on account of the severe action of salt air.

To provide for expansion, sliding joints or connections were made for the longitudinal girders at every third bent, or 60 ft. apart. Openings 2 ins. wide were left in the concrete floor at these bents and filled with asphalt.

A steel shed 54 ft. wide × 993 ft. long, was built on the main wharf directly in front of the custom house.

An overhead foot bridge is provided at the west end of the custom house for the exclusive use of foot passengers. This viaduct connects by stairways, with the first and second floors of the custom house, and at the other end is located a tower for the use of the customs inspector, from which tower can be seen the entire length of the wharf, and all vessels lying there. A broad stairway also leads from the viaduct to the floor of the wharf.

The low portion at the rear of the wharf is crossed by several bascule bridges, carrying push-car tracks, which run from near the face of the wharf into the custom house. These bridges are built in two panels, each about 13 ft. long, hinged at the end and fold up between the shed columns located between the two tracks. They are operated by hand power by means of chain hoists.

### LATERAL WHARVES.

These are very similar in construction to the main wharf, but are, as before stated, lower and only 50 ft. wide. They extend 700 ft. east and west from each end of the main wharf. The cylinder piers are all 6 ft. in diameter, arranged in three longitudinal rows, 19 ft. 8 ins. and 19 ft. 3 ins., center to center, the cylinders in each row being 20 ft. apart. The lengths of the steel shells are 53 ft., 48 ft. and 48 ft. respectively, from the face. The piles driven inside of the cylinders extend in all cases 15 ft. below same into the clean sand. The piles project up into the cylinders 26 to 27 ft. The steel plates are ½-in. thick, except in the upper 5-ft. sections of the two front rows, and the two upper sections of the rear row, where the plates are ⅝-in. thick.

The steel superstructure girders, concrete floor and timbers are arranged much the same as in the main wharf, but on account of the shallower permissible depth, due to the lower elevation of the floor, the longitudinal girders frame into the cross girders instead of resting on top, and all girders are made of very heavy I-beams. The cross girders each consist of three I's 24-in. × 95 or 100 lbs. The regular longitudinal stringers are I's 18-in. × 60 lbs., and the railroad stringers 24-in. × 100 lbs. There are no sheds on the lateral wharves.

### GENERAL DATA.

Heavy iron mooring posts and rings are securely bolted to the cross girders along the face of the entire wharf 60 ft. apart.

The shed is provided with copper gutters and down spouts at every other post, and the wharf has frequent drainage holes over the entire area. It is lighted by 16 arc lamps, supplied with current from the electric light plant of the custom house.

Thirteen hydrants with 2½-in. outlets, located along the inner face of the wharf for fire protection, are supplied with water through an 8-in. main, connecting with the custom house water system.

In the construction of the wharf and auxiliaries, approximately the following material was used:

217,000 lin. ft. of creosoted piling, 2,000,000 ft. of creosoted pine lumber, 25,650 cu. yds. concrete, 10,000 tons of steel, 90 tons of rivets, 280 tons of corrugated iron, and 7,700 gallons of paint. The total area of the wharf is about 129,000 sq. ft.

The storage capacity, not including the car capacity of the tracks, is 34,250 tons. The total length of cylinder piers in place is 20,800 lin. ft.

### EQUIPMENT AND CONSTRUCTION.

On account of the size of the work and the distance from well-equipped machine shops, it was deemed advisable to provide a very complete equipment for this work.

The present main wharf occupies about the same location as the burned wooden wharf, and the old wharf piles were used for supporting staging carrying the various travelers used on the work. The piles were cut off to uniform level, capped with 12 × 12-in. timbers, which carried four lines of 12 × 12-in. track stringers. To these were spiked 56-lb. rails, on which the different travelers for construction purposes were operated. The cylinder sections being brought to the bent on barges, two or three sections, according to the depth of water at place of sinking, were riveted together on the barge, then set in position, and held in place by large wooden clamps attached to the staging. The cylinders were then forced down by pull jacks, and when these were not sufficient were driven by short blows of a 1,500-lb. hammer, working in short leads, placed on top of the cylinders. The material inside of the cylinders was excavated by means of Lancaster grapple dredges.

For sinking the short cylinders of the inner row, the plenum pneumatic process was used to avoid any movement of the sub-soil near the foundations of the custom house, and also on account of the mass of riprap deposited along the outer edge of this foundation. For this purpose an air lock of proper size to bolt to the top of the cylinders and a small traveling derrick operating on a standard gage track were used. The excavated material was hoisted out by a bucket attached to a wire, passing through the top of the air lock.

After the cylinders were sunk to the proper position, from ten to twelve 45-ft. creosoted piles were driven inside of each cylinder. For this purpose, a swiveling pile driver was erected, so arranged that it could be turned completely around on its center, and also arranged on a shifting or transfer table, that allowed it to be transferred from one range of cylinders to another. This transfer table ran upon the same four tracks used by the sinking travelers, and followed in operation immediately behind them. To drive the piles until the butts were at the required elevation, it was necessary to use a 30-ft. oak follower, to one end of which was attached a 14-in. wrought-iron pipe, ½-in. thick, and 6 ft. long, which fitted over the top of the pile.

For driving piles in the cylinders of the inner row of the main wharf, ordinary pile leads with 2,500-lb. drop hammer were used, which pile driver traveled on rollers on skidways immediately over the tops of the cylinders.

Following the pile drivers, and on the same tracks was a traveling platform used on concreting the cylinders.

It was found that although the cylinders were excavated to the cutting edge, and usually below during the sinking operation, that after the piles had been driven in them, they had refilled with sand 4 or 5 ft. Before the cylinders could be concreted, it was necessary to remove this sand, which was done by use of a long 3-in. siphon worked down between the piles. As soon as the sand was cleaned out, sufficient 1 to 2 mortar was placed by means of a tremie in the bottom of the cylinder 4 or 5 ft. deep. This mortar was allowed to set about 24 hours, when it was found that the cylinders were usually completely sealed at the bottom, and could then be pump ! out, and the balance of the concrete laid in the open air.

For the erection of the superstructure, a traveling derrick was used. After the steel superstructure was erected and riveted in place, arched corrugated iron was placed between the floor stringers and the concrete floor placed on top of same. To facilitate the distribution of concrete a traveler was constructed. Concrete was mixed by hand on the barge adjacent to the face of the wharf, was shoveled into skips of about ⅔ cu. yd. capacity, and swung to place by the traveling derrick. This derrick would reach and pick up skips from the barges, and swing same to the extreme inner edge of the low area of the main wharf.

During the preliminary work on the wharf careful and exhaustive research was made in the subject of the best coating for metal in salt water, and it was decided to coat the cylinders in the piers with Assyrian asphalt, applied to the metal while both the metal and asphalt were hot. At first the cylinder shells were so coated, but after being placed in the work gave evidence of peeling, and complete failure, as a protective coating soon occurred, due partially to rapid deterioration caused by salt water, and disintegration, caused by the growth of shell fish. Experiments were then made with various paints, but the time was too short to make any satisfactory tests. The balance of the cylinders of the main wharf were painted with Smith's durable metal coating. The cylinders of the lateral wharves were painted with L. Z. Leiter's air drying paint, with the exception of the two upper sections of all piers, which were galvanized. The paint at the water line has not proved satisfactory, and it would have been better to have galvanized all sections of cylinders above low water.

In order to maintain the depth of water along the face of the wharf, pile dykes were constructed, one projecting into the river from the north shore just above the wharf, and the other from the south shore, a considerable distance above the wharf. The former extended into the river only as far as the face of the wharf, and prevented the water from cutting in behind same. The latter deflected the current from the south side of the river toward the face of the wharf.

The construction of the two dykes is similar, two rows of piles were driven staggered so as to make triangular panels of about 10 ft. The piles were capped and connected by longitudinal string pieces. Planking, 4 × 10, were then bolted to the up-stream side to check the flow of water and turn the current toward the face of the wharf. The piles were sway-braced in both directions.

## THE FIRST INGOT OF MEXICAN TIN.

Some 200 to 300 years ago the Spaniards worked deposits of float or placer tin at a point about 40 miles from Aguas Calientes, Mexico. Last year Mr. W. A. Pratt, who has been an assayer at Aguas Calientes for several years, and his associates discovered a tin vein from which the float tin had evidently come. On Feb. 23 of this year an ingot of tin weighing 50 lbs. was smelted from the ore of this vein. This ingot is believed to be the first ever cast in Mexico.

The vein is said to be about 5 ft. wide, containing stringers of tin, and can be traced for a mile. The vein is said to run from 2½ to 4% tin, which compares well with Cornwall ore, most of which runs less than 1%. There is so small an amount of iron (1%) in this vein that the ore can be economically concentrated and smelted.

Mr. Pratt has organized the Consolidated Tin Mining and Smelting Company of Mexico, and he writes us that shaft sinking and tunneling on the vein are now under way. The address of the company is Aguas Calientes, Mexico.

## THE PROPOSED MUNICIPAL STREET RAILWAY FOR CHICAGO.

The municipal street railway system which the city proposes to organize from lines whose franchises have expired, has already been described in our columns, and the specifications and drawings for the construction, equipment and operation of the system have been prepared by Mr. Bion J. Arnold, Consulting Engineer. These specifications are to govern the bids, which must be submitted by July 1, and call for very substantial work, with numerous interesting details. The main line will extend from Clark and Adams St. to 12th St. and 40th Ave.; the underground conduit system is to be used as far as Robey St., beyond which the overhead trolley system will be employed. The rails along the conduit system will be 9-in. 120-lb. grooved girder rails carried by the conduit yokes; the same rails on concrete beams will also be employed for the trolley system as far as Rockwell St., beyond which the track will consist of 7-in. 85-lb. girder rails, with side-bearing heads, spiked to wooden cross ties. The 9-in. rails are to be in 50-ft. lengths, and the 7-in. rails in 60-ft. lengths. The total length of line will be 5.7 miles, with construction as follows:

| Track: | Miles. |
|---|---|
| Conduit and girder rails | 2.604 |
| 9-in. girder rails on concrete beams | 1.456 |
| 7-in. girder rails on ties | 1.657 |
| Total | 5.717 |
| Paving: | |
| Granite block | 0.912 |
| Asphalt | 1.064 |
| Brick | 1.985 |
| Creosoted block | 0.152 |
| Cedar block | 1.604 |
| Total | 5.717 |

Probable extensions include Halsted St., 1.638 miles of underground conduit; and Ogden Ave., 3.07 miles of trolley line, making a total of 10.425 miles.

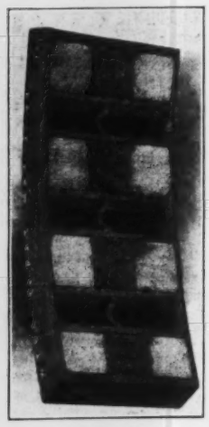
The work will include a power station, substation, office, car house and repair shop, with mechanical and electrical plant complete. The power plant is not designed, but the specifications provide for either steam turbines or compound reciprocating engines, with generators delivering

three-phase, 25-cycle, alternating current at 22,000 volts. The rolling stock equipment to be provided will include double-truck cars seating 48 to 52 passengers, with four motors to each car; also a snow plow and a sprinkler car with 5,000-gallon tank.

It is expected that several bids will be received for the construction, equipment and operation of this municipal street railway system, and the development of the experiment will be watched with interest.

## BRAKESHOE FOR TRUING LOCOMOTIVE AND CAR WHEELS.

When the tires of railway wheels are worn so as to be grooved or to have flat spots they must usually be removed and either turned or ground to the proper form. This not only requires the purchase of special machine tools, and causes delay and expense, but also puts the engine or car out of service for a certain length of time. In order to avoid these troubles, a wheel-truing brakeshoe has been devised which can be fitted to the brakehead when required, and will grind down the face of the wheel while the car is in service. The advantages of being able to grind the wheels true while they are in service are obvious.



Brakeshoe for Truing Up Grooved Car Wheels.

Wheel Truing Brakeshoe Co., Detroit, Mich., Makers.

This brakeshoe consists of a metallic shell filled with an abrasive material arranged in sections alternating with open spaces. The abrasive material, of course, grinds wherever the brake is applied, and the open spaces allow the debris to escape. Its purpose is to true up wheels which need truing, either on account of flat spots or tread wear. For the latter, the abrasive material is arranged in such a manner as to grind only upon the sides which are high, and in the center is placed a soft non-abrasive material corresponding to the part of the wheel which is grooved or tread-worn. This design of shoe is shown in the accompanying cut, but for truing up wheels with flat spots the abrasive material extends over the full width of the tread. These shoes are of a different class from the tire-dressing shoes now extensively used. These latter are really compensating shoes that are designed to act upon that part of the wheel which is not worn by the rail, and thus wear down the flange in accordance with the wear of the tread. The wheel-truing brakeshoe, however, is really a wheel-grinder, made in the form of a brakeshoe, and used as such only while the work of grinding is being done.

The wheel-truing brakeshoe is as yet more extensively used upon electric railways than upon steam railways, but it has already been adopted by a number of the latter. It is now being supplied to over 800 steam and electric railways in the United States and also to several foreign railways. It is manufactured by the Wheel Truing Brakeshoe Co., of Detroit, Mich., and we are indebted to Mr. J. M. Griffin, President and General Manager of the company, for photographs and other information.

## A NEW PLUG DRILL.

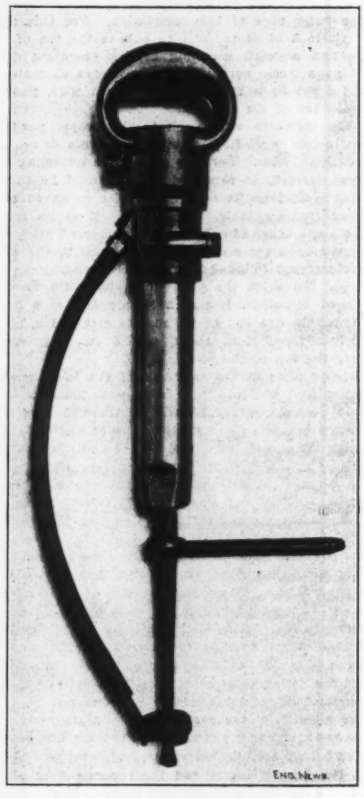
We illustrate herewith the new Dallett Plug Drill for drilling plug and feather holes in rock. The drill consumes 16 to 17 cu. ft. of free air per minute and weighs 20 lbs. As shown in the illustration, the bit is rotated with a wrench by hand. The manufacturers say regarding this feature:

**We have found by some experiments, very expensive to us, that a self-rotating plug drill is not a practical tool, as the advantages of same do not compensate for the complication of the parts necessary to accomplish this object. When a man is operating the tool, but one hand is required to hold it, and the other hand might as well be employed in turning the bit as not.**

It is stated that as high as 450 plug and feather holes in granite have been drilled in 8 hours by one man. When it is remembered that 100 holes drilled by hand is a good day's work for one man, the reason for the growing popularity of plug drills is apparent. Of course the actual time of drilling a hole with a plug drill is less than the above rate (nearly one hole per minute) might lead one to suppose; for there is a large percentage of time consumed in shifting from hole to hole and in getting started. A member of our editorial staff has personal records bearing out the general statements of the manufacturers as above given.

When it is remembered that a small 12-HP. gasoline driven compressor plant will furnish enough air to run four or five plug drills, at a cost of about 12 gallons of gasoline per day, it is remarkable that so many contractors still cling to the expensive work of drilling plug holes by hand. The plug drill is no longer an expensive tool. We note that the one under consideration is listed at $60.

The makers call special attention to the method of locking the barrel in the sleeve by means of a tangent ratchet that prevents the barrel from unscrewing and allowing the valve box to hammer. The tool is provided with a push handle throttle valve, and is very fast running. The manufacturers are the Thos. H. Dallett Co., York and 23d St., Philadelphia, Pa.



A New Pneumatic Plug Drill.

AN EIGHTEEN HOUR TRAIN to Chicago from New York is announced by the Pennsylvania R. R. This train will be run in regular service and will make the run in two hours less time than is now taken by the present fastest train between these two cities. As the distance between the two cities is 897 miles by the Pennsylvania R. R., the new train will have to maintain an average speed of almost 50 miles per hour. To demonstrate the possibility of the new schedule the company on June 5 ran a train from New York to Pittsburg in 8 hours and 50 minutes and another from Pittsburg to Chicago in 8 hours and 10 minutes, thus making the total time from New York to Chicago an even 17 hours.

THE GUNNISON TUNNEL CAVED IN at 10 a. m., May 30, burying eight or nine men and imprisoning 21 between the fallen earth and timber and the [illegible]. The tunnel is being built by contract for the U. [illegible] Reclamation Service, as a part of an irrigation [illegible]. The tunnel will be 30,000 ft. long and will extend [illegible] the Gunnison River to the head of an irrigation [illegible] at Cedar Creek, not far from Montrose, Colo. An [illegible]trated description of the tunnel, with a map, appeared in Engineering News for Sept. 8, 1904. We are [illegible] to Mr. A. P. Davis, Acting Chief Engineer, for [illegible] of official telegrams giving the news of the [illegible] June 1 Mr. I. W. McConnell, Engineer-in-Charge, [illegible]graphed from Cedar Creek, Colo., as follows:

Gunnison Tunnel caved in at 10 a. m., May 30, [illegible] half way between portal and breast Cedar Creek [illegible] Cave occurred 300 ft. from portal while timbermen [illegible] was replacing temporary timbers by permanent [illegible] bers. Twenty-one feet of roof caved in burying [illegible] mass of heavy timbers. Twenty-one men imprisoned [illegible] hind the cave rescued unhurt through shaft at breast at 11 a. m., May 31. Probably nine men buried under [illegible] of whom two were rescued alive yesterday and two were rescued alive to-day. Work of rescue delayed by danger of crushing live men under cave. One dead body taken out to-day. All others will be reached within twenty-four hours. Foreman of timber gang who was buried under cave and rescued can offer no explanation of accident, as all timbers, shores and braces were in excellent condition a few minutes before the accident occured. Cave came without warning and so fast that men were given no chance to escape. Careful inspection indicates no further danger. No permanent work will be disturbed.

The supervising engineer for the district in which the tunnel is located is Mr. J. H. Quinton, of Denver.

A REMARKABLE BRIDGE ACCIDENT recently befell a pin-connected railway bridge over the Connecticut River, at Saybrook, Conn. A pin at one of the top-chord joints lost its nut, and the pin slipped partly out of bearing. To repair the damage, the bridge was jacked up on a scow at the panel points adjoining the point of accident, and new pin-plates, pin and nut put in. It is believed that the accident was caused by the sudden stopping of a freight train on the bridge due to the breaking of an air-brake hose; the train remained on the rails, but put a violent longitudinal stress on the bridge. The span in question is about 150 ft. long, and is part of a single-track bridge about 1,000 ft. in total length. It was built in 1888. A new double-track bridge, to be located alongside the old one, had been contracted for before this accident took place.

FIVE WATER SUPPLY AND SIX GAS AND ELECtricity bills have been signed by Governor Higgins of New York. Of the eleven bills one of each class applies to the whole State of New York and all the others to New York City alone. Of the latter by far the most important is the one authorizing Mayor McClellan to appoint a permanent water commission of three members, citizens of the United States and residents of the city, at an annual salary of $12,000 each. After investigation of available sources of supply the commission is to submit plans to the city Board of Estimate and Apportionment on approval of which the selected source may be acquired by condemnation if necessary. Cities and towns located in counties from which the additional supply is taken are to have the right to tap the aqueduct leading therefrom. Three of the five water bills are designed to guard neighboring counties from the diversion of water by New York City. The fifth water bill creates a State Water Supply Commission, with supervisory powers over the potable waters and the sewage disposal systems of the State. No city or town can acquire land for water supply until plans for the latter have been approved by the State Commission. In its first annual report to the legislature the commission must review the available water resources of the State and the water needs and the sewage disposal of each municipality in the State. This commission is to consist of five members appointed by the Governor, and serving with no compensation except for expenses incurred in their work. The Commission of Gas and Electricity will regulate the gas and electric light supply of the State and will be in many respects like the Massachusetts Commission of twenty years standing. The other lighting bills establish the price of commercial electric and public gas and electric lighting in New York City, establish a range of gas pressure, provide for certain local inspections of the lighting service, and authorize the city to generate electricity in connection with its water supply developments. The appointees to the Commissions are announced in our Personal column.

CONDITIONS OF EMPLOYMENT on the Isthmian Canal work are defined in a recent circular issued by the United States Civil Service Commission and obtainable on application to the Commission at Washington, D. C., with request for Form No. 1463. The following particulars quoted from this circular are of special interest:

Employees Whose Salaries are Fixed on a Monthly or Annual Basis.—The salaries of such employees begin upon the date of embarkation at port of departure from the United States. They will be granted free transportation from port of departure, which includes meals on the steamer, but will be required to pay all expenses of the journey to such city, which are not to be refunded. Where practicable, and in the best interests of the

service they will be provided with such quarters on the Isthmus as may be available from time to time, and if such quarters are not available they will be granted, in lieu thereof, a sum, payable monthly, equal to 15% of their monthly compensation.

Leave may be granted, in the discretion of the head of the Department in which employed, leave of absence at the rate of six weeks for each twelve months of service rendered, or at the rate of 3½ days each full month's service actually rendered, such leave to be accumulated for a period of two years, and to be granted at any time after eight months' service, in the discretion of the head of the Department. If such leave is granted, they will be entitled to the Government rate of $20 each way on the steamers of the Panama Railroad & Steamship Company operating between New York and Colon. This grant of leave of absence is not to be considered a vested right, but is made to promote the welfare and interests of the service, and compensation for the period of their leave will not be paid until after their return to duty.

Employees whose salaries are fixed on a monthly or annual basis will receive no extra pay for overtime work rendered of them.

Employees Whose Compensation is fixed on an Hourly Basis.—Employees appointed with rate of pay per hour will be allowed compensation on a basis of an eight-hour day from the date of departure from port of embarkation until they actually enter upon the performance of their duties, after which time their wages will be based on an eight-hour day, with time-and-a-half for overtime work, including Sundays and holidays, but will not be entitled to any leave of absence with pay. They will be granted free transportation from port of departure in the United States, including meals, but will be required to pay all expenses of the journey to that city, which are not to be refunded. Where practicable and in the best interests of the service they will be provided with such quarters on the Isthmus as may be available from time to time, and if such quarters are not available they will be granted, in lieu thereof, a sum, payable monthly, equal to 15% of their compensation, based on two hundred and eight hours per month.

Medical Attendance.—Free medical and hospital attendance in case of illness is provided.

Return Transportation.—Free transportation is provided to a port of the United States upon the termination of satisfactory service, the character and length of such service to be determined by the head of the Department.

Transportation of Families.—Members of the immediate families of employees will, upon request, when the exigencies of the steamship service permit, be granted the Government rate of $20 between New York and Colon. No charge will be made for children under 6 years of age, and half rates will be charged for children between the ages of 6 and 12 years. Employees will not be permitted to take their families to the Isthmus until they have gone there first and secured quarters for them.

THE CHICAGO DRAINAGE CANAL is to be supplemented by the Evanston and Calumet auxiliary drainage channels, and the Sanitary District has decided to commence the purchase of right of way for both these channels. It is estimated that it will take two years to acquire the necessary land and the rights to cross the 14 lines of railway that will be intersected. Mr. Isham Randolph, Chief Engineer of the Sanitary District, has given out the following particulars of these two auxiliary channels:

| | Calumet. | Evanston. |
|---|---|---|
| Length | 16 miles | 9 miles |
| Width | { 150 ft. in earth / 90 ft. in rock } | 80 ft. |
| Depth | 22 ft. | 12 ft. |
| Capacity, cu. ft. per min... | 225,000 | 60,000 |
| Railways crossed | 11 | 3 |
| Cost of right of way | $750,000 | $1,032,590 |
| Cost of completed work | $12,000,000 | $3,000,000 |

BIDS FOR THE CROSS RIVER DAM received by New York Aqueduct Commissioners on May 31, 1905, ranged from $1,080,319 to $1,344,030, the lowest bidder being Mr. Bart Dunn, 444 East 68th St., New York City. The detailed bids are given under Contract Prices elsewhere in this issue. The dam will be located near Katonah Station, and will be a high structure, of cyclopean masonry, faced with concrete blocks. Mr. J. Waldo Smith, M. Am. Soc. C. S., is Chief Engineer of the Croton Aqueduct Commission.

REPAIR OF THE MAXIMILIAN STONE ARCH bridge at Munich, Germany, has been accomplished without accident, according to a description in the "Schweizerische Bauzeitung" of May 13, 1905. The peculiar accident which befell this bridge in June, 1904, the arches of both spans (144.3 ft. c. to c. of hinges) slipping off their hinges, was described in our issue of Oct. 27, 1904, p. 373. The repair involved raising both spans to their proper position, and replacing a number of damaged portions of the ring masonry. The arches in falling had dropped at the skewbacks a greater distance than at the crown, so that evidently the curvature of the arch-rings had been altered; it was therefore necessary not only to raise the arches bodily, but to spring them into shape by raising more at skewbacks than at crown. A considerable amount of the masonry pier and secondary arch work which carries the roadway had been completed at the time of the accident, and much of this required removing to reach damaged portions. The hinges also required to be modified so as to make recurrence of the accident impossible; this was done by fixing a dowel in one hinge face to engage a recess in the abutting face, whereby sliding is rendered impossible, while the hinge (rolling) action is not affected. In order to make it possible to raise the arches without straining them, it was decided to remove a complete course of voussoirs at intervals along the curve of the arches, thus breaking up the barrels into a series of axial strips of masonry. This was done after the centering (which was still in place, though damaged) had been repaired and strengthened and brought to bearing. The jack screws under the centering of each arch were then inter-connected by ropes to turn in unison, and the arch gradually raised until the crown was at proper elevation. The ends were raised farther by manipulating the screws individually. The courses of voussoirs which had been removed were then replaced, the skewback blocks and the modified hinges put in, and all open joints pointed up.

A SANITARY SEWERAGE SYSTEM FOR BALTIMORE seems assured at last; for the legislature of the State and the people of Baltimore have authorized a $10,000,000 bond issue for that purpose. A sewerage commission will be appointed by the mayor, and the commission will select a chief engineer, after which the method of final disposal of the sewage will be decided. It is not expected that the organization of the commission will be completed before next fall, or that construction will be started before the spring of 1906. Mr. B. T. Fendall is City Engineer of Baltimore.

THE BRONX VALLEY TRUNK SEWER BILL has become a law. It is designed to divert sewage to the Hudson River and provides for a commission, consisting of one member, each, from Yonkers, Mount Vernon and White Plains. The estimated cost of the work is given as $2,000,000.

DEEP PIER FOUNDATIONS were required in constructing a railway bridge over the Barrow River, in Ireland, which is at present nearly completed. The deepest foundation is at a depth of 127 ft. below high-water level, while no less than seven piers were carried more than 100 ft. below high water. The piers were sunk by pneumatic working, with a maximum pressure of 42 to 45 lbs. per sq. in. This pressure was less than the hydrostatic head for the bottom portions of some of the piers, but was considered the highest practicable pressure. The water flowing in under the excess head outside was removed by ejectors.

A TANK REFRIGERATOR CAR of novel design is being introduced by the German-American Car Lines, of Chicago. In exterior appearance it resembles an ordinary box refrigerator car, but inside are four vertical cylindrical tanks 90 ins. diameter, with conical tops and bottoms. The tanks are lined with glass, and have a combined capacity of 7,808 gallons. Each tank has a manhole in the top, made accessible by a trap door in the roof, while the bottom has a pipe connection, accessible from below by a smaller trap in the floor. The sides, floor and roof have double insulation, with hair felt packing, and ice racks will enable milk to be carried. The rated capacity of the car is 90,000 lbs., and the weight is 56,800 lbs.

A PRIVATE RAILWAY MOTOR CAR, operated by steam, has been built by Kerr & Stuart, of London, for use on the Gwalior State Railways, a system of 250 miles of 2-ft. gage railway in India. The car is 31 ft. long over the sills, or 33 ft. 9 ins. over the spring buffers, and the height from rail to top of roof is 9 ft. At the front end is the engine compartment, isolated from the saloon and entered from a front platform. This has a Merryweather quick-steaming boiler, 2 ft. 8 ins. diameter, supplying steam for the engine and a 1½-HP. turbine dynamo for electric light, electric fans and two electric headlights. The boiler is carried by a steel frame mounted on a leading pair of 18-in. wheels and a rear pair of 30-in. wheels. The cylinders are 6 x 9 ins., placed outside, between the wheels, and driving the 30-in. wheels. A Stephenson valve motion is used. The wheel base of the driving truck is 5 ft. 6 ins., and the rear of the car is carried by a four-wheel truck having 18-in. wheels, and 5 ft. wheelbase. All the wheels are fitted with brakes. The body is divided into two saloons, and the entrance is from the observation platform at the rear. The side sheathing is of steel plate, and the exterior is finished in white and gold, while the interior finish and equipment is very elaborate. The boiler has 162 sq. ft. of heating surface and 6.6 sq. ft. of grate area; its pressure is 140 lbs. There is a tank of 150 gallons capacity. The car weighs 12½ gross tons in full working order, and can be run at a speed of 20 miles an hour.

HEAVY TANK LOCOMOTIVES for freight service have been introduced on the Paris Belt Ry., of France, to handle trains on the division between Juvisy and Versailles. The former engines, with six coupled wheels, can only haul trains of 310 tons, or 215 tons on one part of the line, while the new engines can haul 550 tons and 430 tons on grades of 1% and 1.5% respectively. They are of the mastodon or 4-8-0 type, and are four-cylinder compounds of the De Glehn system, with a long tank on each side of the boiler and a coal bunker behind the cab. The high-pressure cylinders are outside the frames, in line with the rear truck axle, and are inclined; they drive the second axle. The low-pressure cylinders (also inclined) are between the frames, under the smoke-box, and drive the first axle. The slide valve of each cylinder is operated by its own valve gear, of the Walschaert system. The principal dimensions are as follows:

| | |
|---|---|
| Driving wheels (8) | 4.72 ft. |
| Truck wheels (4) | 2.62 ft. |
| Wheelbase, driving | 15.58 ft. |
| Wheelbase, total | 27.17 ft. |
| Weight on drivers | 134,440 lbs. |
| Weight, total | 178,640 lbs. |
| Cylinders (4) | 14.8 x 26 ins. and 22.8 x 26 ins. |
| Boiler, diameter | 4.74 ft. |
| Tubes (Serve), 126; diameter (exterior) | 2.8 ins. |
| Tubes, length | 13.45 ft. |
| Heating surface, tubes | 2,055 sq. ft. |
| Heating surface, total | 2,184 sq. ft. |
| Grate area | 25 sq. ft. |
| Water in tanks | 1,600 gallons |
| Coal in bunker | 8,800 lbs. |

FREIGHT CARS OF LARGE CAPACITY in Europe are not likely to supersede the present small cars, except for special classes of traffic, according to a recent paper by Mr. Blaid, Chief Engineer of Rolling Stock of the Eastern Ry. of France. In England the cars are 15 to 16 ft. long, with two axles; they have a capacity of 6 to 10 tons and a dead weight of 5½ to 7½ tons. The practice of forwarding small shipments promptly, the large private ownership of freight cars (about 50% of the total), and the changes at freight yards, coaling docks, mines, etc., which would be necessary to accommodate the large cars, all tend to a continuance of present practice. Some railways, however, are using 30 and 40-ton cars mounted on trucks, and 15 and 20-ton cars on two axles. These are mainly for coal and ore traffic. In Germany a 15-ton car with steel frame and two axles is practically the standard, although some experiments are being made with 40-ton pressed steel cars on trucks, 30-ton cars on three axles, and 20-ton pressed steel cars on two axles. In France 10 and 15-ton cars are used; and there are in service about 20,000 steel cars of 20 tons capacity, on two axles, weighing only 7½ to 7¾ tons. Some 30, 40 and 50-ton steel cars are in use (the 40-ton cars weighing 14 tons), and are mounted on trucks, but Mr. Blaid does not favor the use of trucks for cars of less than 40 tons capacity. He thinks that while in America traffic conditions necessitate the use of very large cars made up into long trains, the conditions in Europe will not warrant the use of large cars to any great extent.

THE ENLARGEMENT OF OFFICE BUILDINGS is one of the features of building construction in Chicago at present. The Hartford Building and the Dearborn Building have both built extensions, and the latter has had additional stories built to bring it to the height of the new portion. The Rialto Building has also had additional stories built, and the same practice has been followed in the Fair store building. The Fisher Building is also to have an 18-story extension. This building, like the Fair, has spread or "float" foundations, but it is proposed to sink caissons under it and put in solid concrete pier foundations reaching down to solid rock; the same style of deep foundations will be used for the new extension. Besides these enlargements, a number of old four and six-story buildings are being torn down to make room for new structures of the modern type.

RAILWAYS IN CHINA, now in operation, aggregate 2,235 miles, according to a recent report by Mr. Cheshire, U. S. Consul at Canton. Besides these, the following roads are under construction: Kaifong to Honanfu (Belgian), Canton to Hankau (American), Tientsin to Cukiang (German), Chingting to Singanfu (Russian), Taiyuin to Chenting (Russian). Concessions have been granted by the government for the following lines: Shanghai to Nanking (English), Hongkong to Canton (English), Suchau to Hwalan (English), Ningpo to Hangchau (English), Tongking to Yunnan (French), Tsinanfu to Kaifungfu (German). The lines now in operation are as follows, with the nationality of the companies owning them:

| Railways. | Nationality. | Miles. |
|---|---|---|
| Harbin to Niuchwang | Russian | 901 |
| Niuchwang to Dalny and Port Arthur. | Russian | 160 |
| Niuchwang to Shanhaikwan | Russian | 150 |
| Shanhaikwan to Tientsin | Chinese | 144 |
| Tientsin to Taku | Chinese | 27 |
| Tientsin to Peking | Chinese | 79 |
| Peking to Hankau | Belgian | 500 |
| Shanghai to Wusung | English | 14 |
| Tsingtao to Tsinanfu | German | 197 |
| Branch to Poshan coal mines | German | 74 |
| Total | | 2,235 |

PETROLEUM BRIQUETTES for fuel purposes are made by a process recently worked out by S. Bö-Un & Co., of Binningen, near Basel, Switzerland, according to a note by Consul George Gifford, of Basel, in the "Daily Consular Reports" of May 27, 1905. The briquettes are made of a mixture of petroleum and a substance whose nature is not disclosed; the materials are preferably used in the ratio of four to one, though it is possible to make briquettes with six parts of petroleum to one part of finative. In the former proportions the briquettes may be stored in piles 50 ft. high without damage. The cost of producing a given weight of briquettes is stated to have been about 20% greater than the cost of the same weight of petroleum in experimental manufacture.

GLASS PAVING AND BUILDING BRICKS are dealt with in a recent series of consular reports. Both bricks and tiles are made by the Societe La Pierre de Verre Garchey, under the Garchey process, and the alles have been used for the walls, floors and stairways of several stations on the Metropolitan Ry. (underground electric line) of Paris. They are of various shapes, sizes and colors, but cannot be cut or drilled, and on the stairs they become slippery with wear. Two streets in Paris have been paved with Garchey bricks, 8 × 3¾ ins., and 1¾ ins. thick, laid on a 6-in. bed of concrete. They do not wear as well as stone, and it is thought that the thickness should be increased to 4 ins. In 1898 a part of the Rue de la Republique at Lyons was paved by the Ceramo-Crystal Co. with "ceramic stone," or glass tiles 8 ins. square and 1 in. thick. In Germany glass bricks are used to some extent for building purposes; they are 2 × 2¼ ins., 5 and 10 ins. long, with dovetailed lugs and recesses so that very little cement is required. Glass blocks set in iron frames are sometimes used in the halls of office buildings to afford light to the basements. In Holland opaque bricks are used for ordinary buildings, and transparent bricks for the walls of machine shops, conservatories, etc. In most cases the bricks are made on the Garchey system, which is patented in most countries. The cheaper qualities are made by remelting old glass bottles, window glass and other scrap. For the higher qualities, glass is first made, then granulated by being thrown into cold water; this material is then put into molds, heated until plastic, shaped in a hydraulic press and then cooled in special ovens.

A VERY LARGE GRAVING DOCK IN JAPAN was completed about three months ago. It is one of a group of three docks of the Mitsu Bishi Dockyard & Engine Works at Nagasaki, and is considerably the largest of the three. Its dimensions are: Length, 710 ft.; breadth, 95 ft.; depth, 38½ ft. The dock lies in solid rock, and required 3½ years for construction.

## PERSONAL.

Mr. E. F. C. Harding has been appointed City Engineer of Jefferson City. Mo.

Mr. John W. Hackney has been re-elected City Engineer of Atlantic City, N. J.

Mr. Fred W. Gow has resigned his position as Superintendent of water-works and sewers of Medford, Mass.

Mr. Charles T. Hayden has resigned his position as Superintendent of the Water and Sewer Board of Rome, N. Y.

Mr. Henry Rohner has been appointed Chief Engineer of the Arkansas Southern R. R., with headquarters at Ruston, La.

Mr. W. C. Swartout has been appointed Division Engineer of the Joplin Division of the Missouri Pacific Ry., with headquarters at Nevada, Mo.

Mr. W. Muir Edwards has been appointed Professor of Engineering in New Brunswick University at Fredericton, N. B. Mr. Edwards at present is connected with McGill University.

Mr. W. D. Hines, formerly Assistant Engineer for the Southern Ry., at Washington, D. C., has resigned that position to become Superintendent of Construction for Wyatt & Nolting, Baltimore, Md.

Mr. B. F. Deuel has been transferred from Newburgh, N. Y., to Jersey Shore, Pa., where he will act as Assistant Division Engineer of the Pennsylvania Division of the New York Central & Hudson River R. R.

Mr. P. H. Falter, formerly with the Niagara works of the Pittsburg Reduction Co., at Niagara Falls, N. Y., has been transferred to the position of Superintendent of the Northern Aluminum Co., at Shawinigan Falls, Que.

Mr. J. H. Travis, formerly Superintendent of Bridges and Buildings of the Missouri Pacific Ry, at Atchison, Kan., has been appointed Superintendent of Buildings and Docks of the Panama Railroad and Panama Canal, with headquarters at Colon.

Mr. Henry-Burnett, late Assistant Manager of the Cuban Railways, has been appointed Superintendent of Transportation, Isthmian Canal Commission, in connection with the construction work on the Panama Canal, with headquarters on the Isthmus.

Mr. Charles E. Goodrich, for some years Chief Draftsman with the Barr Pump Co., of Philadelphia, is now Chief Draftsman for the Worcester, Mass., branch of the American Steel & Wire Co. Mr. Goodrich is a graduate of the Mechanical Engineering Department of Worcester Polytechnic Institute.

Mr. Norman McD. Crawford, M. Am. Inst. E. E., has resigned his position as General Manager of the Hartford Street Ry. Co., of Hartford, Conn., to become consulting engineer with the Consolidated Ry. Co. Mr. Frank Caum, formerly Superintendent of the Hartford Street Ry. Co., succeeds Mr. Crawford.

Mr. David W. Ross, formerly 2d Vice-President of the Illinois Central R. R., has been appointed Purchasing Agent of the Isthmian Canal Commission, with headquarters at Washington, D. C. Major H. J. Gallagher, United States Army, who has been acting as Purchasing Agent, has been appointed Deputy Purchasing Agent.

Mr. J. B. French, Bridge Engineer of the Long Island R. R., is now located at Jamaica, N. Y., and while still retaining charge of the steelwork for the Atlantic Ave. Improvement in Brooklyn, he has also been placed in charge of similar work for the railroad's part of the Bay Ridge Improvement and of all steel construction for the Maintenance of Way Department.

Mr. John F. Stevens, formerly second Vice-President of the Chicago, Rock Island & Pacific R. R., has been appointed Railroad Expert to the Philippine Commission and will accompany Secretary of War Taft on his trip to the Philippines, July 1st. Mr. Stevens will have entire charge and control of the construction of the 1,000 miles of railroad which is to be built in the Philippines.

Mr. Wm. F. Hutson has resigned his position as District Sales Manager of the American Steel Foundries, with offices in Pittsburg. Mr. Hutson has been with the American Steel Foundries since its organization and prior to that with its predecessors, The American Steel Casting Co. and the old Standard Steel Casting Co., which was a part of the American Steel Casting Co., since 1899.

Mr. R. S. Moore for 20 years General Manager of the Risdon Iron Works, of San Francisco, has resigned from the latter company and has bought out the National Iron Works, owned by Marshutz & Cantrell. Mr. John T. Scott, for ten years Superintendent of the Union Iron Works, is also associated with Mr. Moore in the new organization, which under the name of Moore & Scott Iron Works will enter the field of general engineering.

Mr. Frank W. Higgins, Governor of the State of New York, has announced his appointments to the State Commission on Gas and Electricity, the State Water Commission and one of the two additional numbers of the State Railroad Commission. The men named for the first mentioned commission are Mr. James R. Sheffield of New York City, Mr. Lester L. Shedden of Plattsburg, and Mr. John C. Davies of Camden. The State Water Commission is to be composed of Mr. H. H. Persons of East Aurora, Mr. Charles Davis of Kingston, Mr. Milo M. Acker of Hornellsville, Mr. John A. Sleicher of Albany, and Dr. E. J. Lederle, ex-Commissioner of Health of New York City. Mr. George W. Aldridge, the present Secretary of the Railroad Commission, was made one of the additional members of that body.

Mr. J. R. Onderdonk has been appointed Engineer of Tests in charge of a test bureau recently established by the Baltimore & Ohio R. R., at which all work of this character will be concentrated in the future. To this bureau will be submitted for analysis, inspection and test all equipment, materials and appliances bought under specification, and all experiments on equipment, material and appliances will be made under the direction of the Engineer of Tests. Mr. Onderdonk, who is about 36 years old, was graduated from Stevens Institute of Technology in 1889, and entered the service of the Baltimore & Ohio as a draftsman in the Motive Power Department in January, 1890. From January, 1891, to October, 1892, he was Inspector of Materials, and from then until October, 1895, he was Assistant Engineer of Tests. Since then he was Engineer of Tests in the Motive Power Department only.

Mr. J. B. Dickson, hitherto Engineer of Maintenance of Way of the Baltimore & Ohio R. R., has been appointed Chief Engineer in charge of the recently reorganized Maintenance of Way Department, with headquarters at Baltimore, Md. The territory of the Baltimore & Ohio System has been divided into three sections for the work of this department and three new positions of Engineer of Maintenance of Way created, and appointments made as follows: Mr. H. E. Hale, formerly Division Engineer at Baltimore, appointed Engineer of Maintenance of Way of the Main Line System with headquarters at Baltimore; Mr. H. H. Temple, formerly Division Engineer at Pittsburg, appointed Engineer of the Pittsburg System, with headquarters at Pittsburg; and Mr. J. A. Spielmann, formerly Superintendent of the Chicago Division, appointed Engineer of the Wheeling System, with headquarters at Wheeling, W. Va.; Mr. L. P. Rossiter, hitherto Assistant Engineer of the Shenandoah Division succeeds Mr. Temple as Division Engineer, and is in turn succeeded by Mr. F. J. Batchelder. Mr. V. K. Hendricks, previously Assistant to the Engineer of Maintenance of Way has been appointed Division Engineer to succeed Mr. Hale.

### Obituary.

Frank A. Dickson, a civil engineer of St. Louis, Mo., died May 20, in that city.

Samuel C. Miller, at one time Treasurer of the Nicaragua Canal Construction Co., died June 2 at his home in White Plains, N. Y.

Colonel Samuel H. Hawkins, who is said to [have] constructed the Savannah, Americus & Montgo[mery] Ry., from the Alabama capital to the sea, died May [at] his home in Americus, Ga.

Alfred H. Martine, formerly Superintendent [of] Engineer of the Water-Works Department of F[all] River, Mass., died recently at Knoxville, Tenn., [to] which he had been a resident since 1884.

Merritt B. Walley, formerly a resident of W[ilt]own, Mass., was killed recently in an explosion [at a] mine 100 miles west of Denver, Colo., where he was employed as a civil engineer. He was a graduate of Wil[liams] College and was 55 years old.

Captain B. F. Reynolds, for the past 20 years Me[cha]nical Engineer for the Water-Works at Om[aha], Neb., died May 24 at his home in that city. He was [for a] time chief engineer of the steamship Pioneer, which in [1850] went out in search of relics of the Sir. John Frank[lin] Arctic expedition.

Captain R. B. Talfor, Assistant in the office of the U. S. Engineer at Galveston, Tex., died suddenly of heart failure May 20, at Houston, Tex. Captain T[alfor] was 62 years old and had been a resident of Texas for more than 30 years, during all of which time he had been an attache of the U. S. Engineering Office, either at Galveston or Houston.

William T. Lees, Chief Engineer of the 21st [Ward] New York branch of the Consolidated Gas Co., died June 2, at his home in Brooklyn, N. Y. He was a graduate of the School of Mines at Columbia University and had studied at Heidelberg University. He was connected formerly with the New York Gas Co., of which his father Thomas K. Lees was then President.

## ENGINEERING SOCIETIES.

### COMING MEETINGS.

MASTER CAR BUILDERS' ASSOCIATION.
AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 14-21, 1905. Annual meeting at Manhattan Beach, N. Y. Secy., J. W. Taylor, The Rookery, Chicago, Ill.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 19 to 23, 1905. Annual convention at Asheville, N. C. Secy., R. W. Pope, 95 Liberty St., New York, N. Y.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 20 to 23. Annual convention at Cleveland, Ohio. Secy., Charles Warren Hunt, 220 West 57th St., New York, N. Y.

ASSOCIATION OF TRANSPORTATION AND CAR ACCOUNTING OFFICERS.
June 20, 21, 1905. Annual meeting at Toronto, Ont. Secy., G. P. Conard, New York, N. Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
June 28, 29, 1905. Annual meeting at Atlantic City, N. J. Secy., Prof. M. S. Ketchum, Boulder, Colo.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 29-July 1. Annual meeting at Atlantic City, N. J. Secy., Prof. Edgar Marburg, Philadelphia, Pa.

PACIFIC COAST ENGINEERING CONGRESS.
June 29 to July 1. At Portland, Oregon. Otto von Geldern, San Francisco, Cal., or Milnor Roberts, Seattle, Wash.

PACIFIC NORTHWEST SOCIETY OF ENGINEERS.
June 29 to July 1. Annual convention at Portland, Oregon. Secy., Milnor Roberts, Seattle, Wash.

LEAGUE OF AMERICAN MUNICIPALITIES.
August 23 to 25. Annual meeting at Toledo, O. Secy., J. McVicar, Des Moines, Ia.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
August 29, 30, 31, 1905. Annual convention at Erie, Pa. Secy., F. P. Foster, Corning, N. Y.

AMERICAN PUBLIC WORKS ASSOCIATION.
August 30, 31, 1905. Annual meeting at Chattanooga, Tenn. Secy., W. H. Flint, Chattanooga, Tenn.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Sept. 5 to 7. Annual meeting at Montreal, Canada. Secy., Geo. W. Tillson, Brooklyn, N. Y.

ROADMASTERS & MAINTENANCE OF WAY ASSOCIATION.
Sept. 12, 14. Annual meeting, at Niagara Falls, N. Y. Secy., C. E. Jones, C., B. & Q. Ry., Beardstown, Ill.

AMERICAN PUBLIC WORKS ASSOCIATION.—A preliminary list of papers to be read before the first annual convention of this association (Chattanooga, Tenn., Aug. 30-31, 1905), contains the following: "Municipal ownership of Public Utilities," by N. Wingfield; "Public Lettings for the Construction of Public Works," by Prof. G. Jackson; "How To Reduce Insurance Premiums," by W. F. Wilcox; "Electric Light Plants in Connection with Water Works," by J. O. Spear; "Sewerage for Small Communities," by R. C. Huston. Secy., W. H. Flint.

AMERICAN CHEMICAL SOCIETY.—The New York section of the society will hold its annual meeting on the evening of June 9, 1905, at the Chemists' Club, 108 W. 55th St., New York City. Eleven papers are on the program, including two on praesneodidymium, a paper on "The Production of Boron Carbide from Boric Oxide in the Electric Furnace," a paper on "The Preparation of Metallic Magnesium and Calcium by Electrolysis," and one on "The Heat Conserving Qualities of Various Refractory Materials."